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A CONSIDERATION OF THE ROENTGEN DIAGNOSIS OF CHRONIC PULMONARY GRANULOMATOSIS OF BERYLLIUM WORKERS*

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INTRODUCTION

BERYLLIUM, sometimes called glucinum, was discovered by Vauquelin in 1797 and was first isolated in pure form by Wöhler in 1928. Today, its chief source of supply is from beryl, a compound of beryllium aluminum silicate.

With the exception of lithium, beryllium has the lowest atomic weight, 9, of all metals and carries an atomic number of 4. While relatively little specific information regarding its chemical properties is available, it is known to bear a close resemblance to cluminum. Its widely used oxide, BeO, is soluble in acids but is highly refractory and, if fired at high temperatures, becomes very resistant to chemical action. Most of its salts are soluble with the exception of the phosphate; among the salts, the chloride is the most outstanding because of its volatility. Beryllium hydroxide is precipitated by weak alkalies but because of its amphoteric character returns to solution upon the addition of an excess of base. The few organic derivatives of beryllium, notably those with acetyl acetone and acetic acid, are freely soluble in organic solvents and may be readily volatilized without decomposition.

Up to the time of World War II, beryllium occupied a position of small importance to American industry. Today, however, it enjoys a widespread usage, not only in the maintenance of our supplies of strategic war materials and as a link in the chain of atomic energy research, but in the production of a great number of civilian products. Mention of but a few of these last includes: the manufacture of certain alloys of copper, aluminum, magnesium, silver, iron, and nickel, to which the beryllium imparts, where desirable, the properties of good conductivity, retardation of corrosion, high tensile strength, and fatigue resistance; the manufacture of phosphors for fluorescent lamps, neon signs and luminous indicators; the production of incandescent lamps, roentgen-ray and electronic tubes; and the

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fabrication of certain types of crucibles, vitreous enamels, gas mantles, and textiles.

Of essential interest, therefore, is the discovery that a new disease has appeared in workers engaged in certain of these industrial processes. It may become manifest as an acute illness in which the skin, the mucous membranes of the upper respiratory passages, and the lungs are involved, or as a chronic pulmonary disease leading to the development of severe disability and akin to the specific pneumoconioses in that it may be productive of varying degrees of pulmonary fibrosis.

Those cases included in the latter category have been of primary interest to us and were recently labelled at the Sixth Saranac Laboratory Symposium as "chronic pulmonary granulomatosis occurring in beryllium workers." They are characterized primarily by exertional dyspnea, loss of weight, cyanosis, and roentgenographically demonstrable changes within the lungs. Their occurrence has been reported from such diverse industrial processes employing beryllium as the extraction of beryllium from the ore; the manufacture of fluorescent powders, fluorescent lamps and neon signs; various metallurgical operations; and certain projects categorized as research in the production of atomic energy.

Proof that beryllium is the sole etiologic agent involved is yet incomplete. The appearance, however, of an industrial disease syndrome in widely divergent occupational groups related through a demonstrable common exposure to beryllium and the identification either by spectroscopic or chemical methods of an abnormal content of beryllium in the pulmonary tissues of all autopsied cases, strongly suggests that beryllium is at least a fundamental prerequisite to the development of the disease.

In contradistinction, however, to the specific pneumoconioses with which we are familiar, not all industrial processes requiring the use of beryllium have been productive of pathology, and to date all efforts to reproduce the specific lesion in the experimental animal have been unsuccessful. Furthermore, the overall incidence of the disease in exposed personnel is low, and there has been demonstrated no good correlation between the degree of exposure and the occurrence of illness. Indeed, the requisite exposure at times appears extremely slight. This is demonstrated by the so-called "neighborhood cases" who have developed typical disease as a result either of breathing slightly contaminated air through living in the vicinity of plants using beryllium, or from handling for purposes of laundering, the clothes of beryllium workers. Perhaps, as suggested by Gardner,[7] there may be some other and yet unknown contributory factor essential to the evolution of the morbid process as a whole.

HISTORICAL

There are still relatively few reported observations of the roentgen changes occurring in the lungs of workers exposed to the various compounds of beryllium. Weber and Englehart[29] are credited with being the first to report the occurrence of respiratory infections among individuals employed in the extraction of beryllium; subsequently Gelman[8,9] in 1936 described the presence in individuals subjected to the inhalation of beryllium oxyfluoride vapor of a fine nodulation similar to that seen in the first stage of "small noduled" pneumoconiosis and miliary tuberculosis. He further directed attention to the instability of the pulmonary changes, and by inference indicated that some might become chronic through the development of fibrosis. Further references to the problem occur,[2,15] but are sparsely scattered until the report of Van Ordstrand[24] and his associates in 1943, describing the occurrence of a "Chemical pneumonia in workers extracting beryllium oxide."

In this and in subsequent communications[25,26] they describe an acute disease affecting individuals engaged in the extraction at high temperatures of beryllium oxide from crude ore. Its most grave manifestation was the development of an acute

pneumonitis. Roentgenographically visible lesions characteristically developed after a latent period of from two to three weeks following the onset of symptoms and physical signs, and appeared as bilateral and diffuse pulmonary changes, the extent of which varied with the severity of the disease. These changes are described as consisting first of a generalized haziness throughout, followed by the development of irregular areas of mottled infiltration and an increased prominence of the linear markings. After a relatively short but variable period absorption occurred, and the "soft infiltrates" were replaced by large or small conglomerate nodules. Subsequently, in the non-fatal cases, the lungs showed complete clearing in from one to four months.

Mention is made of this acute reaction, now designated since the recent Sixth Saranac Laboratory Symposium as "the acute pneumonitis of beryllium workers," only in the interest of completeness. Its relationship to the delayed or chronic form of the disease is not yet understood, but since it has not to date been identified as a precursor thereof its roentgen characteristics need not be further detailed at this time.

The roentgen manifestations of the chronic form of the disease, prior to its specific designation as chronic pulmonary granulomatosis, have also been described by Sosman and Wilson in a report from Hardy and Tabershaw,[11] by Pascucci,[17] and again more recently by Wilson.[31,32]

INCIDENCE AND CLINICAL FEATURES

The incidence of chronic pulmonary granulomatosis is low even in environments thought to have been productive of other cases. Hardy[12] reports but 36 among 1,400 similarly exposed workers. On the contrary, the "neighborhood cases" dramatically indicate that there is no good correlation between the degree, type or duration of exposure, and the development of disease.

Clinically, the latent period between the time of exposure and the onset of illness is extraordinarily inconstant, and may vary from a few months to more than five years. For a detailed discussion of the symptoms as well as the physical and laboratory findings, reference is made to the excellent papers of Hardy and Tabershaw,[11] Pascucci,[17] Hardy,[12] and Wright and Filley.[34] It may be said, however, that in all except the occasional mild and asymptomatic cases dyspnea is a constant complaint. The dyspnea is usually accompanied by cough, anorexia, weight loss and easy fatigability, and occasionally by fever to 103–104° F. Except for cyanosis and scattered rales the physical findings are not striking. A polycythemia is usually present in all except the mildest cases, and a moderate eosinophilia without an accompanying leukocytosis is common. No predictable deviations from normal in the chemistry of the blood have been discovered. Examination of the sputum is customarily uninformative, although in 13 cases with sputum Wright and Filley[34] demonstrated acid-fast diphtheroids in 2 (one of which showed the same organism on blood culture), a *Monilia albicans* pathogenic for rabbits in one, and tubercle bacilli in one. This last is the only case in which we have observed the development of a complicating pulmonary tuberculosis, although Wilson[33] states that in one of his cases also tubercle bacilli were recovered from the sputum. The relationship of the two diseases, however, is doubtful.

Wright, in his discussion of Hardy's paper,[12] has stated that in those cases suffering from severe dyspnea an impediment to the passage of oxygen across the alveolar membranes is characteristic, and that a loss of breathing reserve occurs in the presence of severe and extensive lesions.

The ultimate prognosis in any given case is indeterminate. The course of the disease is progressive over a period of months to years, with a final termination either in death from respiratory or cardiac failure, or in improvement through a slow regression.

PATHOLOGY

For a summary of the pathology of chronic pulmonary granulomatosis, con-

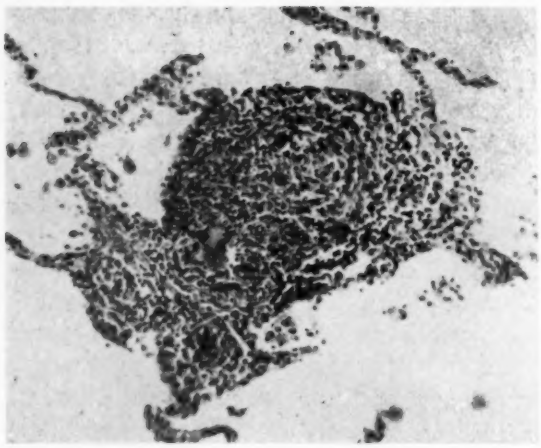

Fig. 1. Photomicrograph of an isolated lesion in the alveolar wall. Note the thickening of the involved septum in comparison with adjacent normal septa. This is an area of relatively slight involvement and shows the nature of the lesion more clearly than does a heavily involved area. The lesion is composed chiefly of macrophages and lymphocytes, the former predominating centrally, the latter peripherally. A multinucleated giant cell is seen to the left of the center. (200×)

stant reference is made to Vorwald's[27,28] description of its pathologic manifestations. Characteristically, these consist of a diffuse chronic inflammatory or granulomatous type of reaction, with scattered nodular lesions localizing primarily within the walls of the alveoli, but occurring also within the septa and adventitial tissues of the blood vessels and bronchi. The alveolar walls are thickened by the presence of macrophages, lymphocytes, plasma cells, and at times by an overgrowth of connective tissue which may subsequently undergo an advanced degree of hyalinization. Multinucleated giant cells are also a common component of the lesions. As a result either of the continued cellular or fibrotic reaction, or both, the normal architecture of the lung is obliterated in cases showing extensive involvement. Some of the alveoli are small, in areas of relative consolidation, while others are dilated and emphysematous.

The "unit lesion" of the process may be categorized as a nodular granuloma, the cellular components of which have been described above, and it is only upon the demonstration of this lesion that a pathological diagnosis can be made. Grossly, these granulomas are rarely more than 1 mm. in diameter and they are distributed with considerable regularity throughout both lungs. Microscopically (Fig. 1) there is an appreciable histopathologic variation between cases and between different sections of the lung in the same case. In most lesions the response is primarily cellular, whereas in others the presence of connective tissue proliferation and hyaline fibrosis predominates. In any given case all the variations in structure of the unit lesion are likely to be encountered, and there is no good correlation between the age of the process and the prominence of its contained fibrosis. Pathologically, therefore, the justification is meager for attempting to identify in roentgenograms stages in the evolution of the morbid process as a whole. By the same token one can expect but little information from the roentgenogram regarding prognosis, except as the outlook may be affected through an estimation of the extensiveness of involvement.

The tracheobronchial lymph nodes are usually enlarged and soft, and on microscopic examination reveal the presence of occasional tiny granulomas identical to

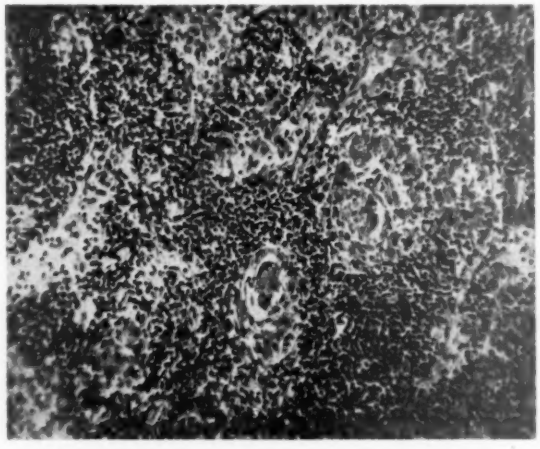

Fig. 2. Bronchial lymph node. Note the rather poorly defined groups of macrophages within which are scattered lymphocytes. The peripheral zone of lymphocytes, seen in the pulmonary lesion, is masked by the presence of lymphoid tissue. (200×)

those seen in the lungs (Fig. 2). In some cases similar lesions are sparsely distributed through the systemic lymph nodes, spleen, liver, and bone marrow.

ROENTGEN MANIFESTATIONS

The roentgen manifestations of chronic pulmonary granulomatosis are extremely protean and for convenience of description require at least some attempt at classification. As a consequence, two or three[11,31] types are generally recognized. These are:

(1) Granular
(1) Reticular
(3) Nodular

In all three the involvement is diffuse, though not necessarily uniform, throughout both lungs.

The three forms are difficult of precise definition, and the inadequacy of such a method of empirical subdivision upon the basis of roentgenographic findings is clearly appreciated. On the other hand, and after considerable thought, there appears to be nothing more informative to suggest at the present time. Perhaps after the etiology and pathology of the disease as a whole are more definitively documented by experimental means, it may be possible for the radiologist to use these more specific data as the basis upon which to formulate a new and more satisfying classification. As long, however, as these limitations are borne in mind, one may with justification present a description of the various roentgenologic forms of the disease as we now know it.

The *granular form* presents on the roentgenogram a generalized stippled or "fine sand-paper" appearance. This is at first suggestive of pulmonary edema, but closer inspection shows it to be "distinctly particulate" in nature. The changes are invariably generalized, though at times they are more apparent in the middle thirds, where at least occasionally there may be demonstrated as a late phenomenon a progressive tendency to coalescence, with the formation of densely confluent areas of infiltration. These latter simulate to some extent

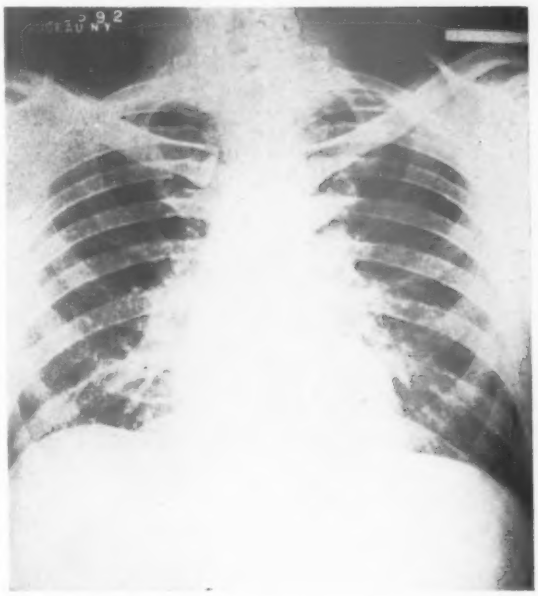

Fig. 3. Generalized, bilateral, particulate granularity in a fluorescent lamp worker, aged forty-nine. Note the absence of hilar lymphadenopathy or increased prominence of the linear markings.

the pattern of the acute pneumonitis of beryllium workers, but their chronicity belies their being the manifestation of an acute disease. It has been suggested[31] that they may represent a transition stage, and that some cases, originally acute, may ultimately evolve into the chronic form. This thesis is distinctly interesting and useful as a stimulus to further investigation, but to date it has neither been confirmed nor denied.

In the granular form there is no apparent enlargement of the hilar lymph nodes and no exaggeration of the linear markings. Indeed the latter, depending upon the density of the process, may be partially obscured.

Figure 3, illustrative of the granular form of the disease, is the film of a forty-nine year old male exposed to the inhalation of zinc beryllium silicate through the screening of phosphors used in the manufacture of fluorescent lamps. His presenting symptoms of exertional dyspnea and easy fatigability were relatively slight, but his roentgen findings are characteristic. They are well nigh impossible of satisfactory repro-

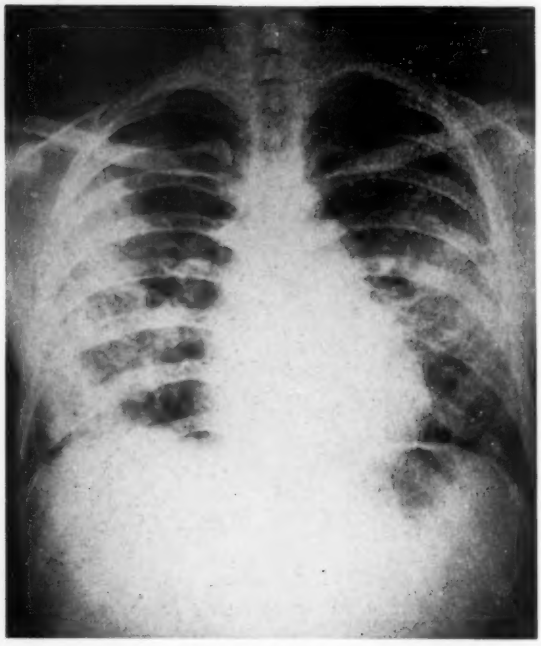

Fig. 4. The granular form of chronic pulmonary granulomatosis, showing in addition to the characteristic granularity areas of "confluent" infiltration in the lower portions of both lungs. (Same case as shown in Fig. 11.)

duction, but consist of a generalized and bilateral particulate granularity, having the appearance of fine sand-paper. No evidence of reticulation, coalescence, nodulation, or hilar lymphadenopathy is seen.

In Figure 4 there is the same granular pattern observed in the former case. In addition, however, there is a pronounced tendency to coalescence, with the formation of confluent infiltrations in the middle and lower portions of both lung fields. Again, the absence of hilar lymphadenopathy is to be noted, but in this case there is a moderate prominence of the pulmonary conus.

At times the granular pattern is preserved and is seen to occur in conjunction with a generalized reticulation comprising the reticular form of Sosman and Wilson.[11] In these, a slight to moderate enlargement of the hilar lymph nodes may provide an additional distinguishing characteristic. As in the granular form, a moderate coalescence of the infiltrations may occur.

Figure 5 is the roentgenogram of a thirty-six year old fluorescent lamp worker whose onset occurred some three years following the beginning of his presumably harmful exposure. His roentgenogram is illustrative of the *reticular type*, in which there may, as in the former group, be observed a bilateral diffuse granularity, but in addition an overlying generalized reticulation. Moreover, the hilar shadows are indistinct and somewhat enlarged, the result of a slight but definite lymphadenopathy.

Figure 6*A* provides another example of the reticular form in a worker who, after five years' exposure, developed the familiar symptoms of dyspnea, cough, and weight loss. His films present not only the characteristic granularity and generalized reticulation, but also a tendency to coalescence in the mid-lung fields. On both the conventional and body section roentgenograms (Fig. 6*B*) there is apparent a moderate degree of hilar lymphadenopathy. Some eighteen months later (Fig. 6*C*) his films showed a slight clearing. In connection with this

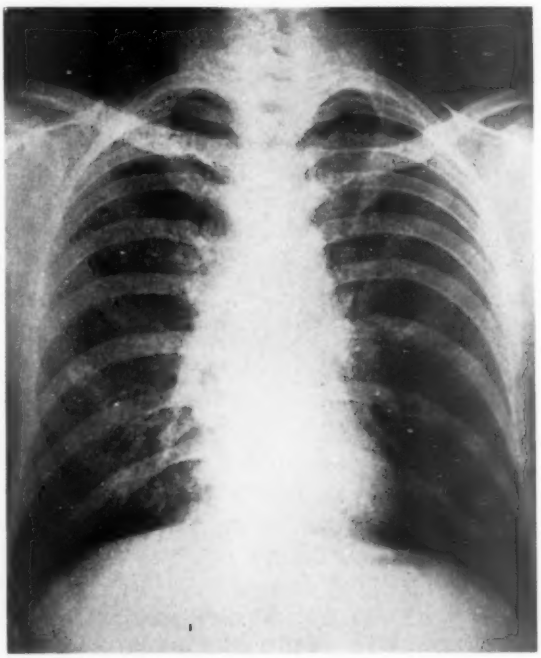

Fig. 5. The reticular form of Sosman and Wilson,[11] showing a generalized reticulation overlying the same type of granularity observed in the preceding case. Here the hilar shadows are indistinct and slightly enlarged.

observation, however, it is pertinent to note that in the interim between examinations his physical deterioration progressed, and there was a further loss of respiratory reserve.

The *nodular type* of chronic pulmonary granulomatosis is characterized by the presence in the roentgenogram of a diffuse nodulation distributed more or less evenly throughout both lungs. The nodules may vary from 1 or 2 to 4 or 5 mm. in diameter in different individuals, but in a given case are generally quite uniform in size. The hila are frequently ill-defined and present a hazy appearance; they are usually the site of a decided lymphadenopathy, although this is not an invariable corollary finding. There is little tendency to actual coalescence of the nodular shadows, although in the upper lung fields a quite definite concentration of the nodules may occur. When present, this latter phenomenon may be associated with either an elevation of the interlobar fissures or with an upward displacement of the hilar shadows, or both. These findings suggest, as do the areas of diminished density described by Sosman and Wilson,[11] the presence of a coexistent pulmonary emphysema. The massive emphysema of the tuberculosilicotic, however, has not been observed. The common absence of demonstrable pleural and pleuropericardial reaction is worthy

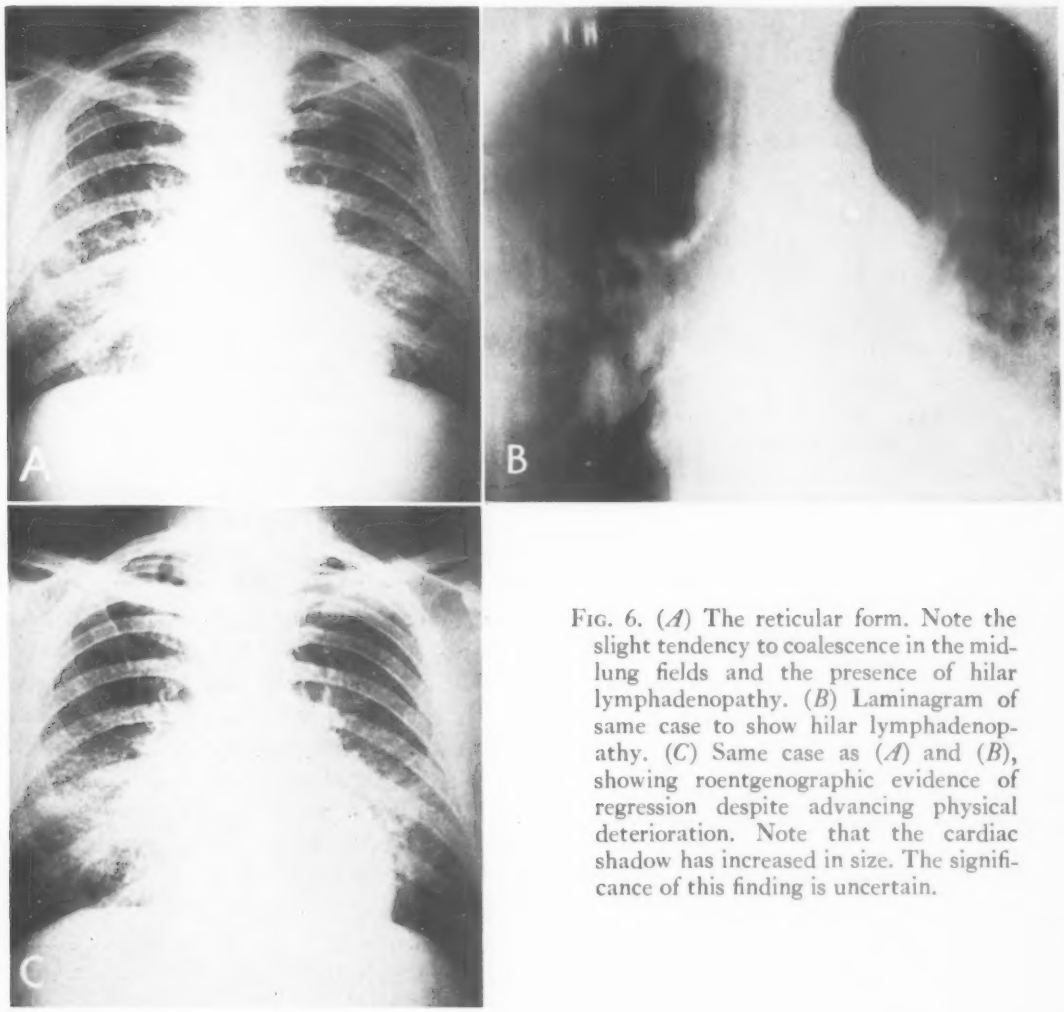

Fig. 6. (*A*) The reticular form. Note the slight tendency to coalescence in the mid-lung fields and the presence of hilar lymphadenopathy. (*B*) Laminagram of same case to show hilar lymphadenopathy. (*C*) Same case as (*A*) and (*B*), showing roentgenographic evidence of regression despite advancing physical deterioration. Note that the cardiac shadow has increased in size. The significance of this finding is uncertain.

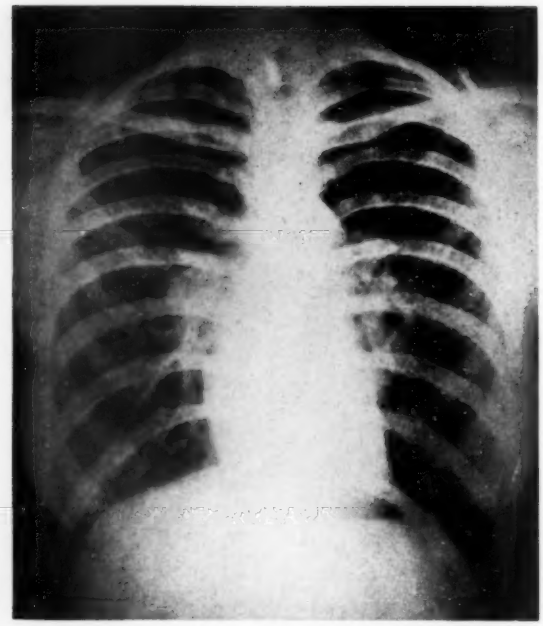

Fig. 7. The nodular form of chronic pulmonary granulomatosis. Note the preservation of a distinct underlying granularity and the marked enlargement of the hilar shadows.

of comment, although nothing in the pathology of the process would appear to preclude their occurrence.

It is further noteworthy that in the nodular type the granularity which has come to be regarded as characteristic of the disease is frequently retained. In our experience, however, and especially in those cases exhibiting gross nodulation, it may be absent or so obscured as to make its identification extremely difficult. In these cases particularly, the problem of differential diagnosis becomes additionally perplexing.

Figure 7 illustrates the nodular form of chronic pulmonary granulomatosis, in which there is a coexisting pronounced enlargement of the hilar shadows. The pattern produced by the parenchymal lesions is distinctly nodular, but differs from that seen in the nodular pneumoconioses in that the nodules are less well defined and are associated with an underlying diffuse granularity. In this instance the latter is quite well preserved.

In contradistinction, Figure 8 lends validity to the statement that in the nodular type of delayed pulmonary granulomatosis the granular background for the nodulation may either be absent or extremely difficult of demonstration. In this case the nodules appear quite discrete, and the roentgen changes closely resemble those of simple silicosis. The patient, however, had had no exposure to free silica and he presented the classical symptoms of the disease now under consideration. It is further interesting to note that during a three year period of observation the changes in his roentgenograms remained virtually static (Fig. 8*B*) despite a pronounced clinical improvement. Again, in this individual, body-section roentgenograms were useful in delineating the extent of the hilar lymphadenopathy (Fig. 8*C*).

One additional example (Fig. 9*A* and *B*) of the nodular form shows a progressive concentration of the nodulation in the upper lung fields. This occurs without any actual coalescence, but may be associated, as in this case, with an elevation of the interlobar fissures and upward dislocation of the root shadows.

To date the period of observation has been too short and the opportunity for follow-up studies too limited to warrant definite conclusions concerning the end results of the pulmonary lesions. In some, there has been a steady progression to a fatal termination. Hardy[12] reports 6 deaths in her series of 36 cases from a fluorescent lamp industry, and quotes Jackson as having observed 5 in a series of 7 cases occurring in a metallurgical firm. In others, the roentgen changes have remained relatively stationary, either with or without clinical improvement, and in still others there have been varying degrees of clearing. In any case there is apt to be a striking lack of correlation between the clinical and the roentgen findings.

COMPLICATIONS

Of the complications which may occur during the course of illness from chronic pulmonary granulomatosis, acute respiratory infections are the most common.

Symptomatically they exert a temporary deleterious effect, but following recovery the patients revert to their status prior to the attack.

Only once have we felt that we observed the development of a superimposed nonspecific pneumonitis. In this case our first film (Fig. 10*A*) exhibited a pattern of gross nodulation without a striking coexistent granularity. Some four months later the patient's symptoms—severe from the beginning—became more acute and were associated with the development in his roentgenogram (Fig. 10*B*) of an area of dense infiltration in the lower portion of the upper third of his left lung. Treatment with penicillin was promptly effective and, in due course, his films revealed only the changes demonstrable prior to his acute illness. It was our feeling at this time that he had been the victim of a complicating acute nonspecific pneumonia. He was lost to observation for approximately one year, and upon his return little change could be demonstrated except that there had occurred a definite tendency to concentration of the nodulation in both upper lungs, together with an elevation of the interlobar fissure

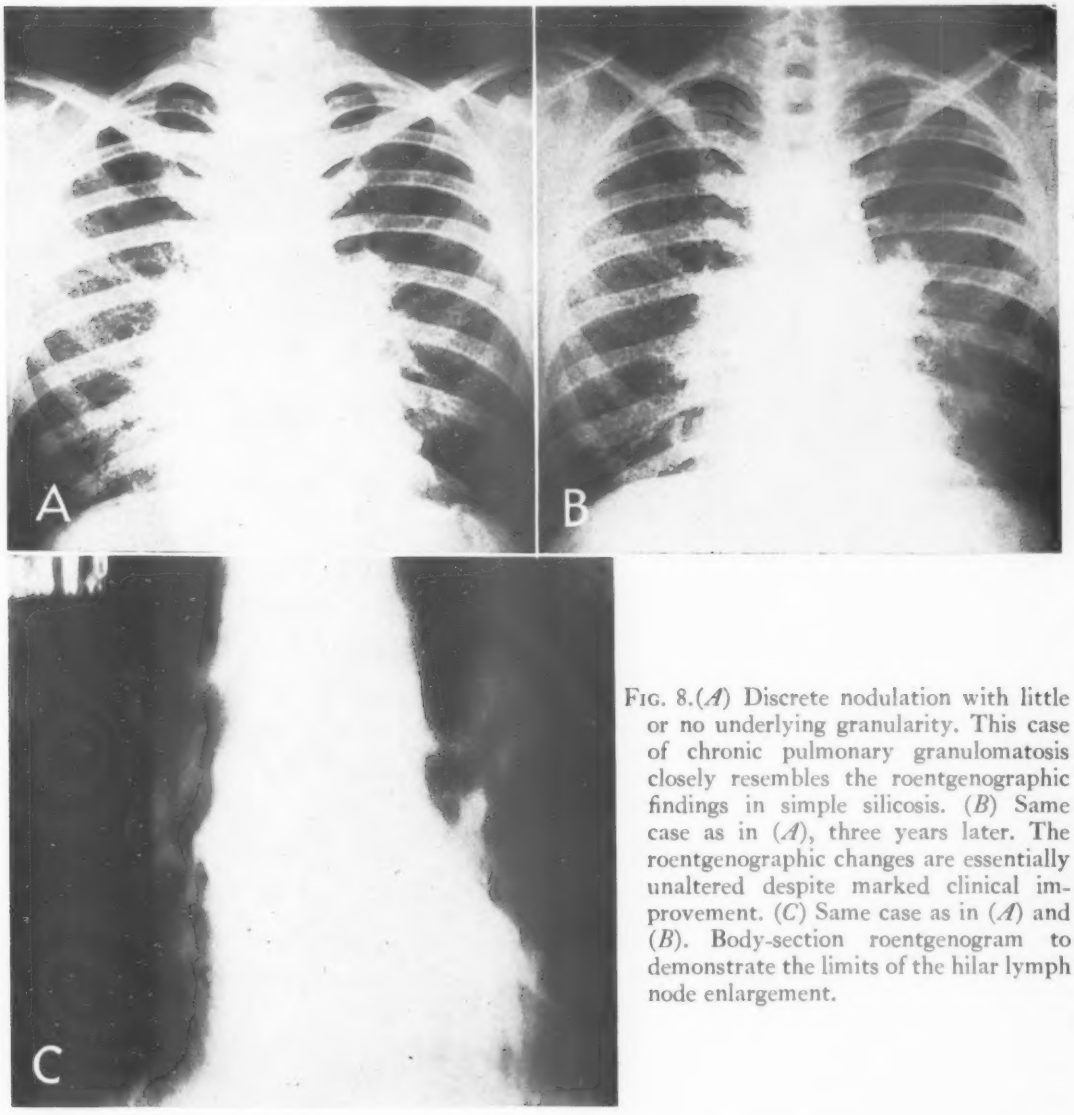

FIG. 8.(*A*) Discrete nodulation with little or no underlying granularity. This case of chronic pulmonary granulomatosis closely resembles the roentgenographic findings in simple silicosis. (*B*) Same case as in (*A*), three years later. The roentgenographic changes are essentially unaltered despite marked clinical improvement. (*C*) Same case as in (*A*) and (*B*). Body-section roentgenogram to demonstrate the limits of the hilar lymph node enlargement.

on the right (Fig. 10*C*). It was observed that this concentration was somewhat more pronounced in the area of his previous "pneumonia." This localization subsequently became more apparent, leading one to suspect that it was associated with a parenchymal infiltration (Fig. 10*D*), and fifteen months after the acute illness described above tubercle bacilli were recovered from his sputum. This is the only case of chronic pulmonary granulomatosis studied by us that has developed a complicating tuberculous infection. Neither process has appeared to exert an untoward effect upon the other. The patient, while still incapacitated, has survived two episodes of a right-sided spontaneous pneumothorax (Fig. 10*E*) and is now definitely improved. His roentgenograms, however, do not reflect his clinical progress. The tuberculous component of the process has cleared appreciably, but the previously existent nodulation is still present and has become progressively more concentrated in the upper lung fields (Fig. 10*F*).

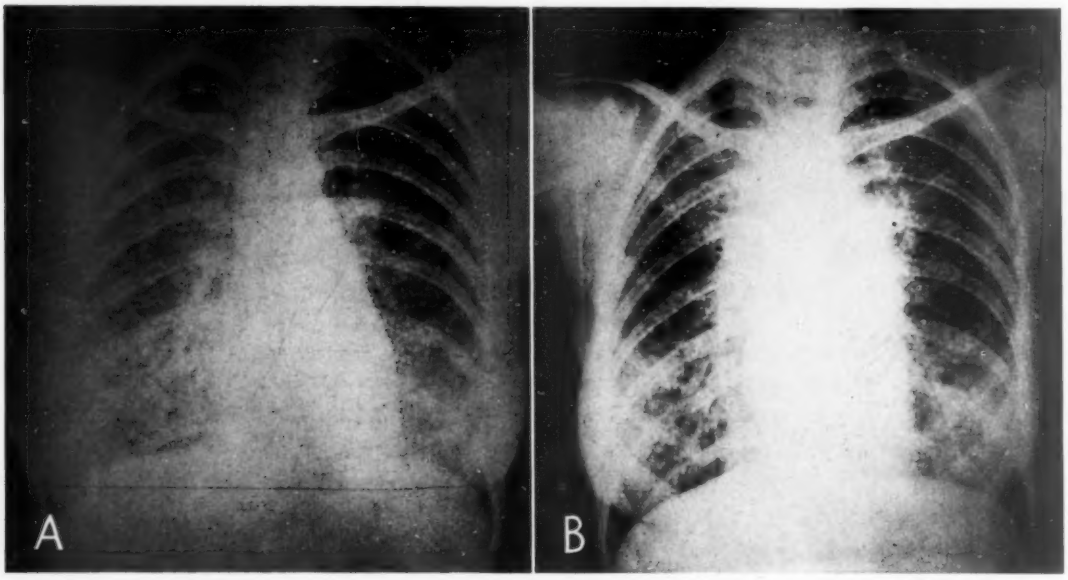

Fig. 9. (*A*) and (*B*). The nodular type with progressive concentration of the nodulation in the upper lung fields over a period of twenty-two months. The concentration is slightly more pronounced on the right and is associated with elevation of the hilar shadows bilaterally.

In the fatal cases, cardiac complications with congestive heart failure and cor pulmonale are common.[31,32,34] In those who survive, however, they are a relatively infrequent occurrence.[34] One is unable to state with certainty whether the late cardiac complications, including cor pulmonale, are an integral part of the disease process or whether they are purely secondary phenomena appearing as a consequence of respiratory failure.

Spontaneous pneumothorax is not seen with the same regularity as in Shaver's disease, but is not unusual. We have observed it only in the case complicated by a coexisting tuberculosis, but Wilson[31] reports it seven times in a series of 50 cases.

Pregnancy in 3 cases and renal calculi in 2, have been listed as complications by Hardy.[12]

DISCUSSION

The various roentgenographic patterns which have now come to be associated with chronic pulmonary granulomatosis occurring in beryllium workers have been described. Before proceeding to the problems of differential diagnosis, however, it is timely to present in discussion several questions

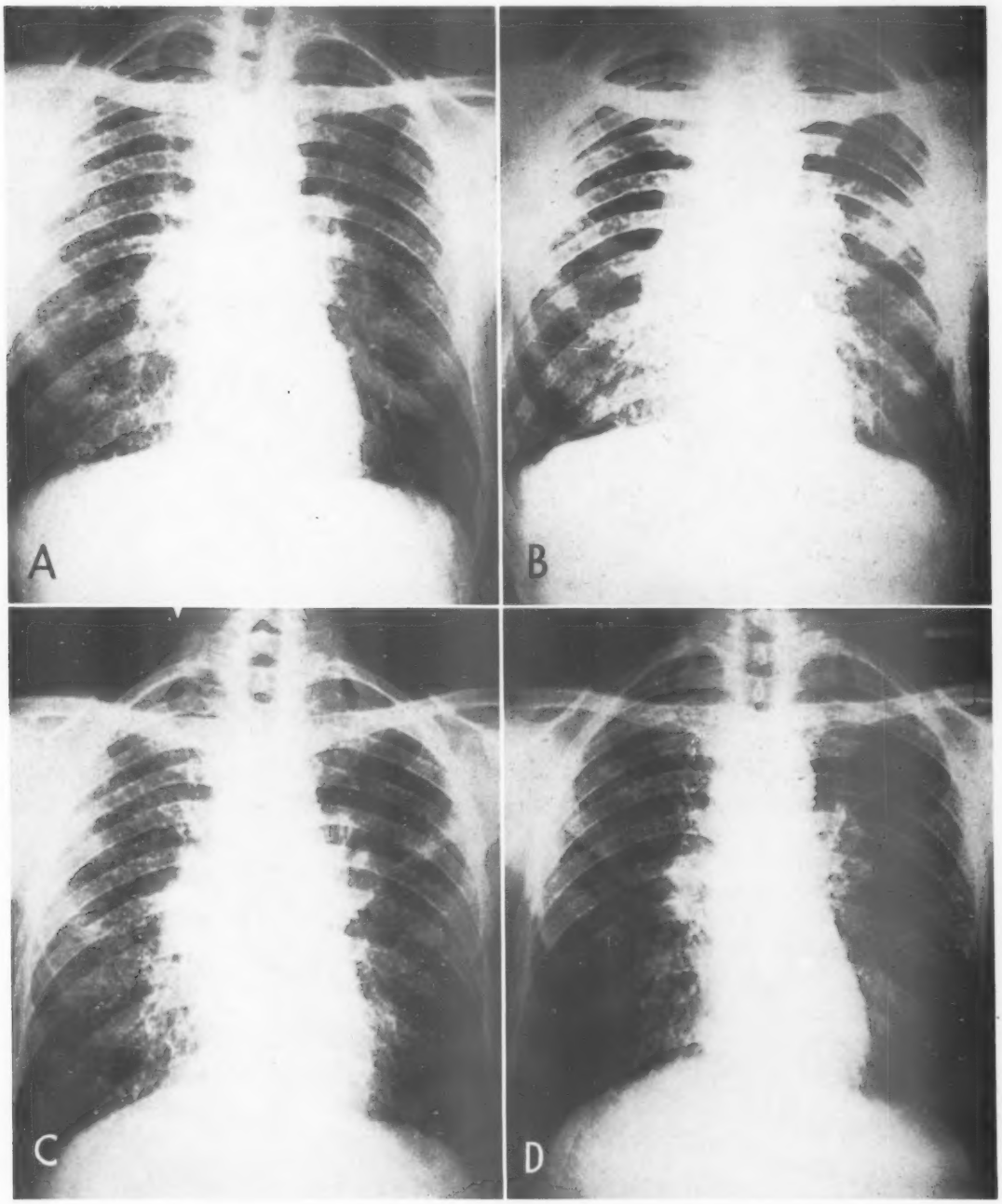

Fig. 10. (*A*) Gross nodulation without a demonstrable underlying granularity in a case of chronic pulmonary granulomatosis.

(*B*) Same case four months later, showing the development of a dense parenchymal infiltration within the left lung. This was thought at the time to be the result of an acute nonspecific pneumonia.

(*C*) Same case one year later, showing clearing of the parenchymal lesion on the left. Note, however, the bilateral tendency to concentration of the nodulation within the upper lung fields, and elevation of the interlobar fissure on the right.

(*D*) Same case. The localization in the left lung at the site of the previous "pneumonia" has now become sufficiently pronounced to allow the identification of another coexisting parenchymal lesion. The sputum subsequently became positive for tubercle bacilli.

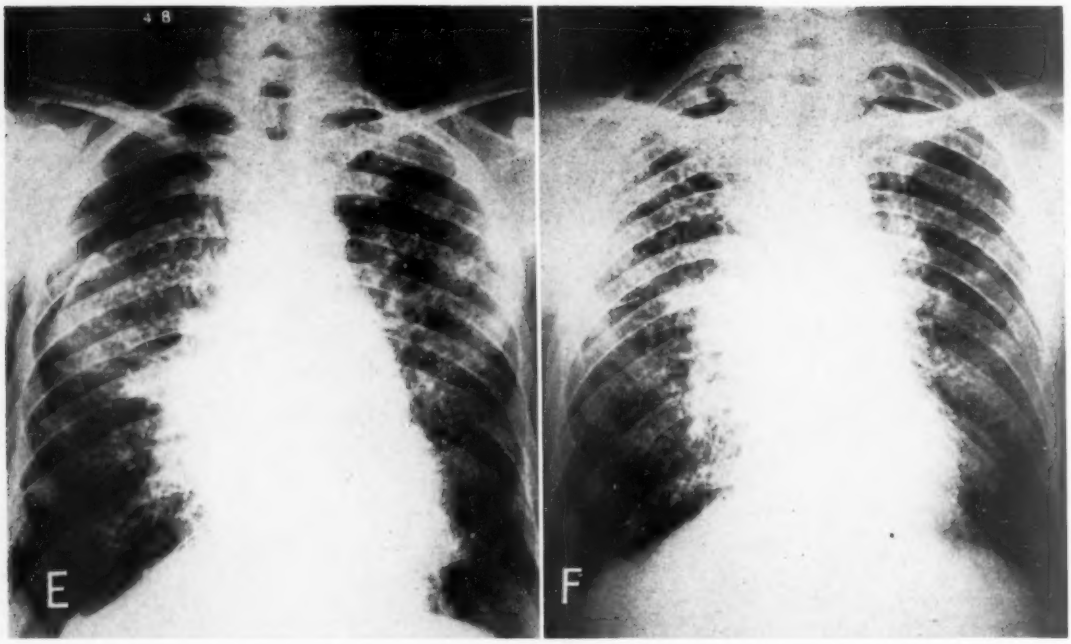

Fig. 10. (*E*) Same case, showing the presence of a spontaneous pneumothorax on the right.
(*F*) Same case, showing pronounced clearing of the tuberculous lesion on the left. The concentration of the nodulation in both upper lungs has become slightly more apparent.

which seem worthy of investigation and further consideration.

First, and generally recognized, is the necessity for determining whether beryllium is the sole etiologic agent involved in the development of disease, or whether it is merely a contributing though necessary prerequisite. If it be the latter, then the "x-factor" which the late Dr. L. U. Gardner[7] was seeking to uncover at the time of his death, must be identified. Also, in the event that beryllium is specifically indicted, the establishment, if possible, of safe levels of exposure, follows as an obvious corollary. Tremendous research efforts are now being applied to the solution of these aspects of the problem.

Second, it is open to question whether the attempt by some[11,31,32] to classify the disease according to stages is justified. The suggestion is advanced that in the light of our present incomplete knowledge it would be more appropriate to regard its protean manifestations as varying types or degrees of tissue response to similar though not necessarily identical irritants. Freely granting the possibility that the various bizarre forms of the disease may represent different phases in its evolution, subdivision into types rather than stages would seem wiser until more extended observation enables us to detect a certain general pattern in its developmental cycle. To date it has not been possible for us to regularly demonstrate a distinct transition from one form to another, and there is no clear-cut succession of stages through which any given case must pass. In this regard, reference is again made to the pathology of the process whereby it is recalled that in any one case, all the variations in structure of the unit lesion are likely to be encountered, and there is no good correlation between the age of the process and the frequency with which fibrosis can be demonstrated. It would seem, therefore, that the factors of paramount importance are the nature of the lesion, the extensiveness of the involvement, and the patient's inherent ventilatory and circulatory capacities, rather than a roentgenographic estimation of the "stage" of development of the pulmonary lesions.

Third, there is some but as yet meager

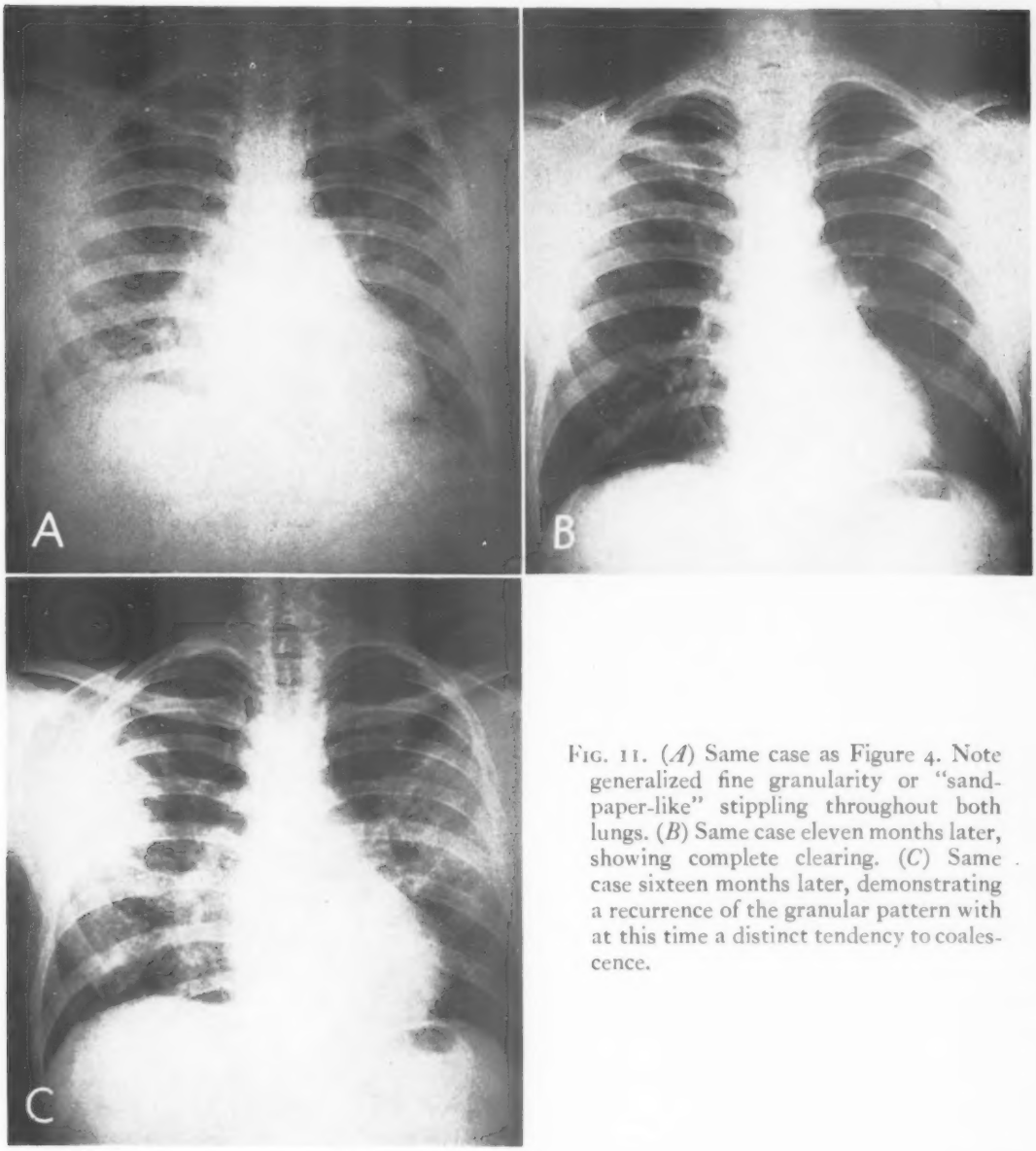

Fig. 11. (*A*) Same case as Figure 4. Note generalized fine granularity or "sandpaper-like" stippling throughout both lungs. (*B*) Same case eleven months later, showing complete clearing. (*C*) Same case sixteen months later, demonstrating a recurrence of the granular pattern with at this time a distinct tendency to coalescence.

indication that the types now recognized are all late manifestations, and that prior to the development of chronic pulmonary granulomatosis there may be a preliminary and perhaps transitory phase, comparable to the acute form but so mild in degree that it escapes recognition. One case will serve to illustrate. The patient, a white male, aged twenty-nine, in November and December of 1942 manually sifted fine fluorescent powders, and in December became ill with symptoms of dyspnea, cough, anorexia and fever. In January, a roentgenogram of his chest (Fig. 11*A*) showed a bilateral, fine sandpaper-like granularity or stippling. His symptoms gradually cleared and he was permitted to return to work as an outside maintenance man where his exposure to beryllium containing dusts was almost but not completely eliminated. The roentgenograms showed clearing, and by November, 1943, eleven months following onset, films of his chest were interpreted as showing nothing abnormal (Fig. 11*B*). After a little more than a year, however, his symptoms recurred. Again roentgenograms of

his chest (Fig. 11*C*) showed a bilateral granularity or stippling throughout, with this time the added finding of coalescence of the infiltration in the middle thirds of both lung fields. During eighteen months of sanatorium residence his symptoms remained much the same, but serial roentgenograms revealed a gradual progression of the pulmonary lesions (Fig. 4). It has perhaps preliminary phase of the disease which in individuals subjected to less extreme exposures than this man may have been so mild as to have escaped recognition? If so, what relation might such a preliminary phase bear to the acute pneumonitis of Van Ordstrand and his associates? Also, would complete interruption of exposure have prevented the subsequent develop-

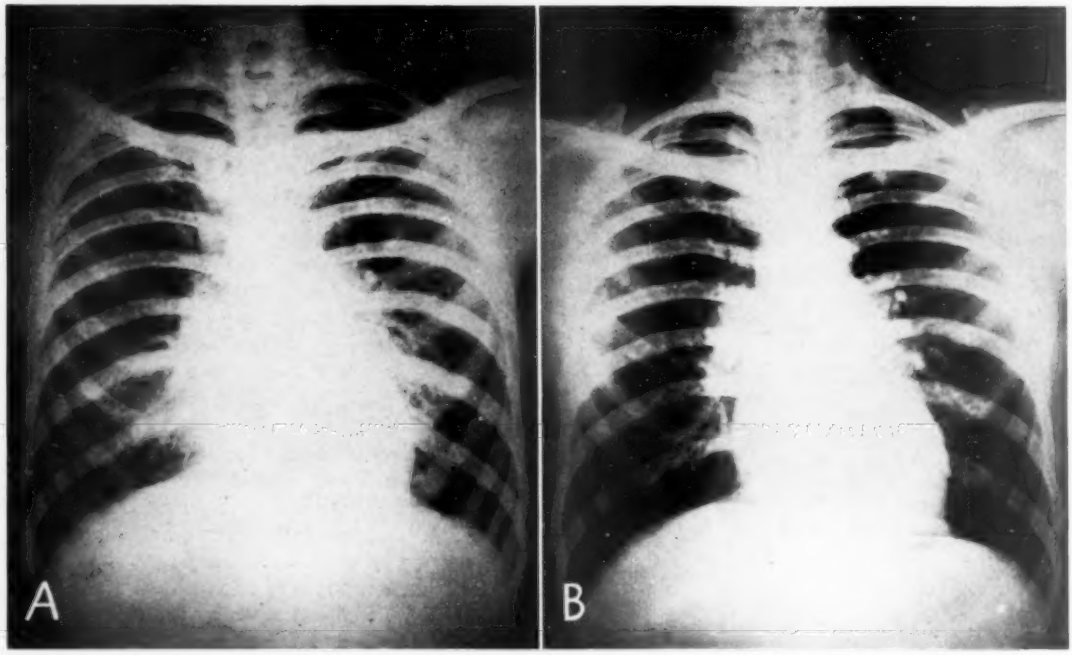

Fig. 12. (*A*) The granular form of chronic pulmonary granulomatosis in a twenty-five year old fluorescent lamp worker complaining of severe dyspnea, cough, anorexia, and weight loss of 24 pounds. Note the absence of demonstrable hilar lymphadenopathy or increase in the linear markings. (*B*) Same case as in (*A*). Symptoms have abated and roentgenograms reveal evidence of marked clearing. There is a residual faint granularity which is not susceptible of reproduction.

not been possible to obtain follow-up films, but it is surprising to learn that he has improved clinically and that he has been able to resume light work.

The course of this man's disease is unique in our experience, but may be most instructive. We are well aware of the variable and oftentimes long latent period that may elapse between the beginning of the presumably harmful exposure and the development of symptoms. Is it not possible that frequent serial roentgenograms of others, taken prior to the development of symptoms, might have uncovered a similar and ment of disability, or is the occurrence of chronic pulmonary granulomatosis the inevitable outcome, once the foundation for the disease has been laid? The answers are probably available through frequent serial roentgenographic examinations of all exposed individuals and through painstaking follow-up studies in such cases as the one illustrated in Figure 12*A*. The symptoms in this case have subsided and serial roentgenograms have shown appreciable clearing (Fig. 12*B*). He should, however, be followed to detect evidences of a possible recurrence as in the former case; or of progression, in

the absence of continued harmful exposure. It is to be lamented that the mechanisms for such follow-up studies remain inadequate, and that the general trend appears to be away from any more than annual roentgenographic examinations on asymptomatic but exposed personnel. It is my opinion that these inadequacies may delay unreasonably a comprehensive understanding of the problem as a whole.

Fourth, it should be emphasized that, despite the presence in most cases of a characteristic granularity occurring in conjunction with other findings, the roentgenogram alone does not present a picture sufficiently characteristic to warrant an unequivocal diagnosis. As in the pneumoconioses, the roentgen manifestations, along with the symptoms, physical and laboratory findings, and the occupational history, must be subjected to critical correlation. It has already been indicated that further attempts must also be made to define, if possible, what may be considered as constituting an adequate history of exposure. Once this is established, the problem will be simplified; but we must yet be wary lest individuals presenting roentgen findings compatible with a diagnosis of chronic pulmonary granulomatosis, but suffering from another disease, be wrongly diagnosed. May this not have already happened to occasional individuals who present few or no symptoms but who show suggestive roentgenographic changes and who have worked in an environment presumably productive of other cases?

Two cases will serve to illustrate. Both had worked in the same plant, both had handled the same beryllium-containing compounds. The first (Fig. 13) is a twenty-two year old woman who had no symptoms but who was accidentally discovered to show in her chest roentgenogram a bilateral granularity with fine nodulation and distinct prominence of the hilar shadows. The second (see Fig. 5) is a male, aged thirty-seven, who complained of severe symptoms of dyspnea, cough, fatigue, and loss of weight, and who on study was found to have a secondary polycythemia, an interference with proper blood oxygenation, and a markedly decreased exercise tolerance. Except for the extent of involvement and the somewhat more definite nodulation in the second, the roentgenographic findings in the two individuals are quite similar. Perhaps they both reflect the changes of chronic pulmonary granulomatosis. Because of the absence of symptoms, however, one is justified in being doubtful of the former, and in suggesting that she may be suffering from simple sarcoid or from some other and less ominous disease. On the other hand, the important factor may simply be one of a difference in the extent of involvement. One cannot be sure, particularly since it is known that in this as well as in certain other diseases such as silicosis, the roentgen findings cannot be used as a measure of disability.

Fig. 13. Bilateral granularity together with fine nodulation and hilar lymphadenopathy (see Fig. 5).

DIFFERENTIAL DIAGNOSIS

For purposes of emphasis, it is reiterated that despite the occurrence in most cases of chronic pulmonary granulomatosis of a granular pattern, the roentgenogram alone does not present a picture sufficiently characteristic to warrant a definite diagnosis.

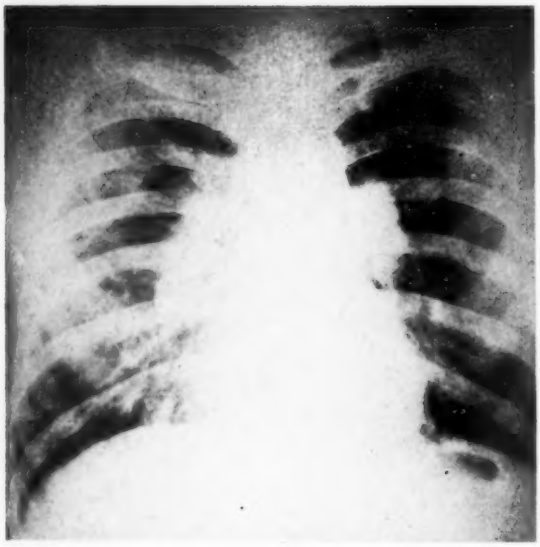

Fig. 14. Pulmonary sarcoidosis of the so-called miliary type, with a slight bilateral tendency to confluence of the parenchymal lesions and with marked hilar lymphadenopathy. The finely nodular form of chronic pulmonary granulomatosis with a granular background is closely simulated. The lesions in this case cleared in a period of eighteen months.

There are accordingly a number of widely varying conditions—granulomatous, infectious, pneumoconiotic, cardiac, and miscellaneous—which must be considered in the differential diagnosis.

Granulomatous. In this category *Boeck's sarcoid* or *pulmonary sarcoidosis* may present an extremely difficult problem. The similarity of the two diseases is indicated by the earlier nomenclature in which that type of chronic pulmonary granulomatosis now under consideration was captioned "beryllium sarcoid."

Boeck's sarcoid is fundamentally a systemic disease, classically presenting widespread involvement of the lymph nodes, viscera, osseous system, skin, and lungs. Its pulmonary manifestations, as reflected in chest roentgenograms, are in turn variable and depend largely upon the phase of evolution of the disease process at the time of observation. Following the lead of Reisner[22] and Bernstein and Sussman,[3] and without any implication that the process is at any time static, its roentgen findings may be classified into several types: (1) that, in which the one visible abnormality is a bilateral and commonly symmetrical enlargement of the hilar and tracheobronchial lymph nodes; (2) that, frequently referred to as "miliary sarcoidosis," in which there are widespread nodular densities evenly distributed throughout both lungs, which densities may in turn exhibit a moderate tendency to coalescence with or without associated hilar lymphadenopathy; (3) that, in which there is hilar lymphadenopathy together with string-like infiltrations radiating outward therefrom into the pulmonary parenchyma; and (4) that, in which there are diffuse, fibrosis-producing pulmonary infiltrates superimposed in many instances upon a background of increased linear markings and nodulation.

It is the miliary type illustrated in Figure 14, in which we have a generalized nodulation together with a marked bilateral hilar lymphadenopathy, and the type such as that seen in Figure 15, with diffuse parenchymal infiltrations and areas of confluence, that tax our ingenuity in the differential diagnosis of chronic pulmonary granulomatosis.

Infectious. Acute pulmonary infections

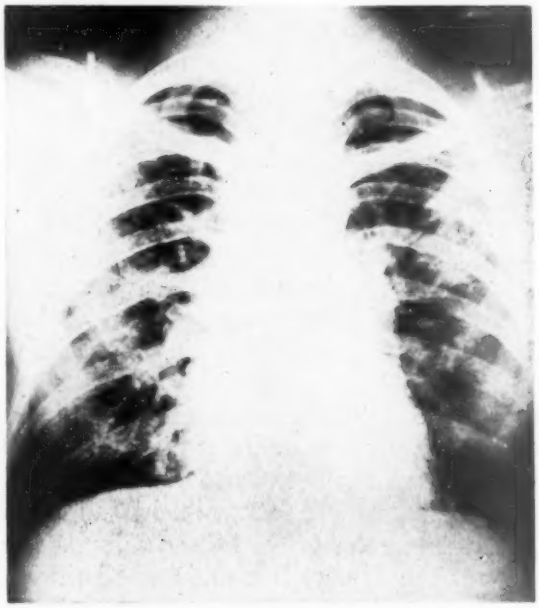

Fig. 15. The diffuse parenchymal infiltration of pulmonary sarcoidosis with bilateral areas of confluence. (Reproduced by permission of Dr. George W. Wright.)

are ordinarily non-productive of chronic sequelae, and by their behavior and distribution may readily be distinguished from chronic pulmonary granulomatosis. They need not, therefore, receive further consideration at this time. Such, however, is not the case with chronic pulmonary infections and with tuberculosis, the protozoan infections, and the bronchomycoses in particular.

Tuberculosis in its common forms, characterized by the presence of irregularly distributed but usually apical infiltrations, with or without cavitation, does not present a problem. On the contrary, it may, following a hematogenous dissemination, exhibit on the roentgenogram (Fig. 16) an evenly distributed nodulation occasionally indistinguishable from the nodular type of chronic pulmonary granulomatosis. Frequently, however, an aid to the differential diagnosis is the identification in tuberculosis of an accompanying localized parenchymal infiltrate or cavity.

Mycotic and protozoan infections, including coccidiomycosis, histoplasmosis, sporotrichosis, moniliasis, aspergillosis, blastomycosis and actinomycosis, may in this discussion be considered broadly in one group. With perhaps two exceptions—coccidiomycosis and histoplasmosis—the mycotic infections have been observed in such relatively small numbers that it has not been possible to formulate a description of their roentgenographic manifestations that may be regarded as sufficiently characteristic to allow for accurate differentiation of one from the other, except upon the basis of bacteriologic examination. They are, however, as a group common enough to justify a high index of suspicion in all cases where roentgenograms reveal either diffuse or nonspecific pulmonary changes. Their roentgen manifestations are extremely variable, but commonly include enlargement of the hilar lymph nodes and chronic intrapulmonary infiltrations prone to the development of fibrosis and disseminated miliary lesions. It is these latter that primarily require differentiation from chronic pulmonary granulomatosis.

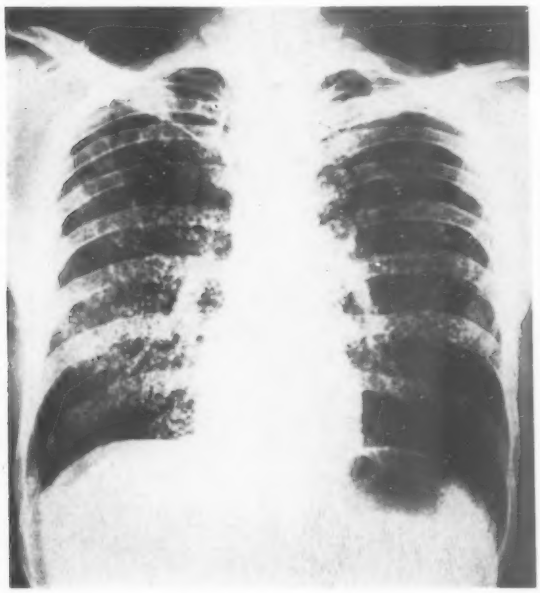

Fig. 16. Generalized hematogenous tuberculosis closely resembling the nodular type of chronic pulmonary granulomatosis. Compare with Figure 7.

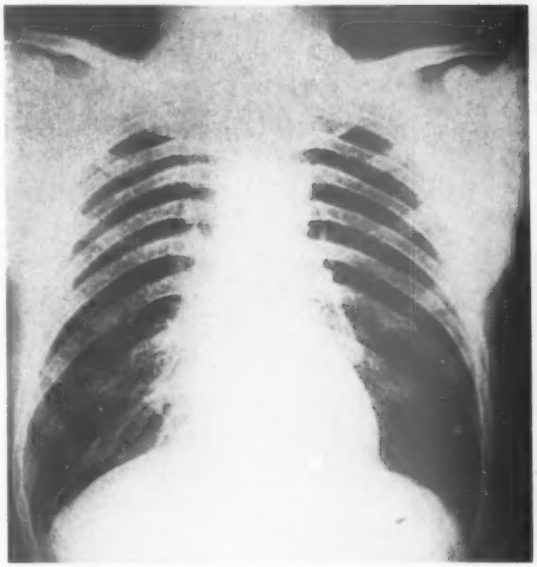

Fig. 17. The generalized fine nodulation of early simple silicosis.

Silicosis is a specific pneumoconiosis resulting from the specific action within the lungs of chemically free silicon dioxide in finely divided form and is characterized by the development of a progressive pulmonary fibrosis. Its diagnosis rests primarily upon a history of adequate exposure, and

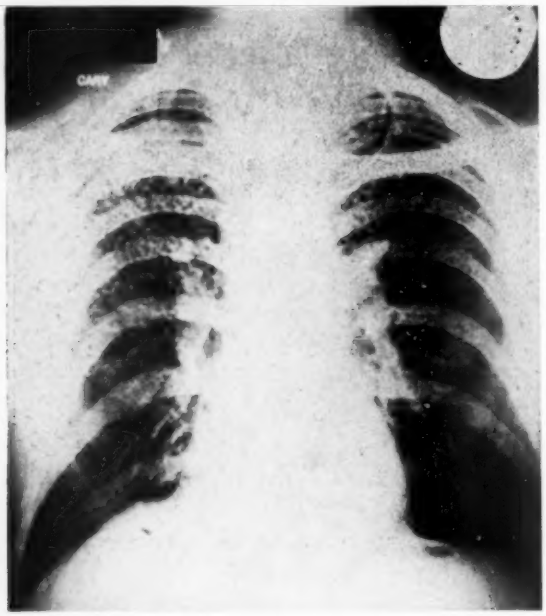

Fig. 18. Tuberculosilicosis, showing "concentration" of the nodulation. Compare with Figure 9*B*.

the roentgenologic demonstration of a characteristic nodulation uniformly distributed throughout the pulmonary parenchyma (Fig. 17). There may or may not be an associated enlargement of the hilar lymph nodes, despite the fact that it is in the lymphatics that the earliest silicotic nodules are known to develop. The pattern of simple silicosis may duplicate that seen in the nodular form of chronic pulmonary granulomatosis and require differentiation by means of history, physical and laboratory findings.

The presence of coexisting tuberculous infection radically alters the picture of simple silicosis.[20] Tuberculosilicosis in but one phase of its evolution, however, is likely to simulate chronic pulmonary granulomatosis. It is not uncommon to discover in the roentgenograms of silicotic individuals, in addition to the characteristic generalized nodulation, areas of linear fibrosis occurring as the residuum of a pre-existing and presumably tuberculous infection. About these fibrotic foci there may ensue a gradual concentration and coalescence of the nodulation, with ultimately the formation of the "massive shadows" of conglomerate fibrosis so typical of tuberculosilicosis. During the phase of "concentration of the nodulation" the tuberculosilicotic process may closely resemble the nodular form of chronic pulmonary granulomatosis in which "concentration of the nodulation" may also occur (Fig. 18).

The benign pneumoconioses, of which, among others, siderosis and baritosis may be considered as typical examples, also require differentiation from chronic pulmonary granulomatosis. They have been appropriately designated by Gardner[6] as benign "roentgenologic conditions," and are unproductive either of physical disability or of progressive pulmonary fibrosis. They do, however, produce a roentgenologically demonstrable diffuse and bilateral pseudonodulation[5,19] (Fig. 19). The nodular pattern develops from the direct visualization of compact collections of radiopaque particles within the lungs.

Asbestosis, also a specific pneumoconiosis, results from the inhalation of asbestos fibers and is characterized by the formation of a progressive interstitial pulmonary fibrosis. The roentgen findings are chiefly

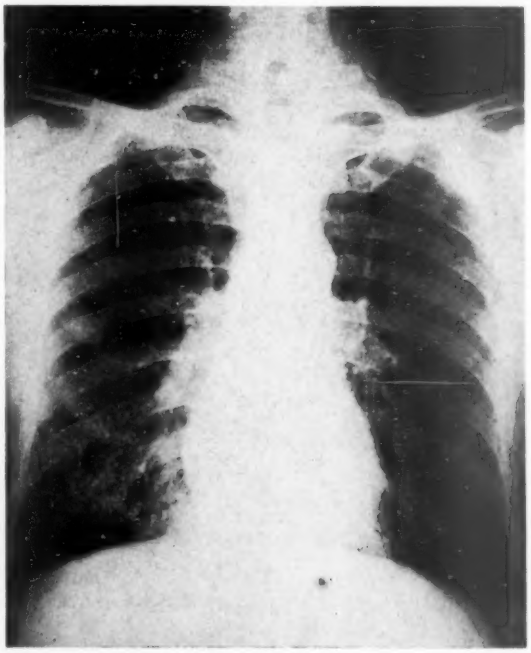

Fig. 19. The pseudonodulation of siderosis occurring after many years of exposure to the fumes of electric arc welding. (Reproduced through the courtesy of Dr. George W. Wright.)

basal, and consist primarily of a "ground-glass" appearance of the lung fields, a partial obliteration of the lung markings, and thickening of the pleura with the formation of diaphragmatic and pleuropericardial adhesions (Fig. 20). It deserves mention not because it is likely to provoke difficulty in differential diagnosis, but because the "ground-glass" appearance in the lower lung fields is somewhat reminiscent of the granularity seen in chronic pulmonary granulomatosis.

Shaver's disease[23] may also be included among those diseases of industrial origin requiring differentiation from chronic pulmonary granulomatosis. It occurs in the manufacture of alumina abrasives and is characterized primarily by pain in the chest, cough, dyspnea, and frequent pneumothoraces either unilateral or bilateral. The roentgenographic changes in the lungs are diffuse. They consist of coarsely granular and string-like infiltrations, widespread emphysematous bleb formation, and the progressive and sometimes rapid development of extensive pleural and pleuropericardial adhesions. Its possible relationship to silicosis is not yet understood. The following quotation from Shaver, however, may be of significance:

> A chemical analysis of Arkansas bauxite indicates that it contains Al_2O_3 80 per cent, SiO_2 5 per cent, and a further group of chemicals in rather small amounts. The fume, on the other hand, shows Al_2O_3 50 per cent and a relative increase in SiO_2 to 35 per cent. An analysis of the lung ash from postmortem material shows the same relative proportion of alumina and silica as the fume.

Cardiovascular Diseases. The most common pulmonary manifestations occurring secondary to heart disease are those of passive congestion and pulmonary edema. Ordinarily, these may be dismissed in the differential diagnosis of chronic pulmonary granulomatosis. On the other hand, that group of cases classified as rheumatic pneumonitis with pneumosiderosis may present a very definite problem. The associated presence of an abnormal cardiac silhouette is helpful, but the pulmonary manifestation

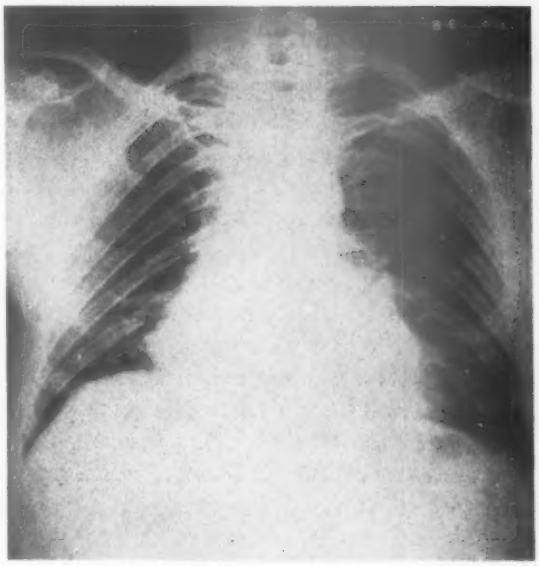

Fig. 20. Asbestosis.

of pseudonodulation may on occasion strikingly resemble the changes seen in the nodular form of chronic pulmonary granulomatosis. This condition has been studied by a number of observers, who describe as the specific pulmonary lesion of rheumatic fever the occurrence of a "perivascular pneumonia"[10] with associated focal hemorrhagic alveolar exudates.[18] These latter in turn lead to the development of local areas of perivascular fibrosis containing hemosiderin pigment derived from the extravasated blood,[1,16] and are presumed to account for the visualization in roentgenograms of a miliary type of pseudonodulation. Pendergrass and his associates have recently reported 6 cases, with autopsy confirmation in four.[21] They demonstrate that the roentgen appearances may be identical with those of the nodular pneumoconioses.

Another and rare cardiac disease conceivably of interest in the differential diagnosis of chronic pulmonary granulomatosis is that which occurs in association with scleroderma. The presence in these cases of focal areas of fibrosis, which impart to the lungs a "peculiar, diffuse, granular or mottled appearance," has been described.[30]

Miscellaneous. In the group of miscellaneous conditions to be considered in the differential diagnosis are: hematogenous or

lymphogenous disseminations of carcinoma, erythema nodosum, and periarteritis nodosa.

In blood-stream disseminated or miliary carcinoma there may occur poorly defined nodular densities evenly distributed throughout both lungs. The individual lesions vary in both size and density, and may or may not be associated with hilar lymph node involvement secondary to a concomitant lymphatic spread.[4] In lymphangiectatic carcinoma the distribution is less uniform. The individual lesions appear to arise as direct extensions radiating outward and toward the bases from enlarged hilar lymph nodes.

Erythema nodosum may generally be considered as an allergic phenomenon appearing during the course of a number of diseases, including tuberculosis, the bronchomycoses, and infections with streptococci, gonococci, and meningococci. Its pulmonary manifestations have been described[13] as consisting of marked hilar lymphadenopathy together with either a miliary type of nodulation or a coarsely linear striation. In either case the lesions are thought to originate within the intrapulmonary lymphatics.

Periarteritis nodosa is generally a fatal disease presenting widespread obliterative or necrotizing lesions of the smaller arteries, arterioles, and veins. Its etiology is probably diverse, but possibly results from the occurrence of irreversible allergic changes within the blood vessels. Its pulmonary manifestations are not well documented, but the occurrence of small conglomerate areas of increased density at the bases and diffuse infiltrations radiating outward from the hila have been described,[14] as have the occurrence of pleural effusions and frequent deaths from bronchopneumonia. Muscle biopsy remains the most reliable antemortem method of diagnosis.

In none of these briefly mentioned diseases in the miscellaneous group is the differentiation from chronic pulmonary granulomatosis likely to be difficult. They do, however, serve to emphasize the fact that in chronic pulmonary granulomatosis as in other diseases a critical correlation of all available data is fundamental to the diagnosis.

SUMMARY

(1) The chemical properties of beryllium insofar as they are known are summarized.

(2) The recently acquired and increasing importance of beryllium to American industry is indicated.

(3) The appearance of a new disease, chronic pulmonary granulomatosis occurring in beryllium workers and characterized primarily by dyspnea, cough, anorexia, loss of weight, and roentgenologically visible lesions within the lungs is described.

(4) The incidence, clinical features, and pathology of the disease in question are briefly surveyed; its roentgen manifestations are detailed. It is suggested that more frequent serial roentgenograms of all exposed personnel and more careful "follow-up" studies of those individuals now lost to observation would add considerably to our current knowledge of the epidemiology and behavior of the disease and would accelerate an eventual understanding of the problem as a whole.

(5) The differential diagnosis of chronic pulmonary granulomatosis and other conditions which may be productive of diffuse lesions within the lungs, is reviewed.

(6) The necessity for a critical correlation of the roentgen findings with all other available data is stressed.

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A TYPE OF PNEUMOCONIOSIS*

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IN A previous report concerning pneumoconiosis found in talc miners,[19] it was inferred that a number of silicates including talc may have in common the ability to cause pulmonary fibrosis when very fine particles in heavy concentrations are inhaled over a considerable period of time. In reviewing the old material and considering new observations, there appears to be a remarkable resemblance between talc pneumoconiosis and authoritative descriptions of the better known, silicate produced disease, asbestosis.

HAZARDOUS SILICATES

Among the silicate dusts that have been implicated in the etiology of pulmonary fibrosis are basalt, reported by Badham,[1] fuller's earth, reported by McNally and Trostler[15] and asbestos and talc which are to be considered in some detail. In his description of the pneumoconiosis found in the miners of basalt, Badham employed the term "silicatosis," to which Gardner[6] objects because the term is too inclusive, most of the silicates having not been incriminated clinically and having been shown experimentally to be inert. Middleton[16] reviewed the evidence against the dusts of asbestos, sillimanite, china clay, talc, mica and sericite and concluded that silica "combined with bases as silicate, appears to cause come change in pulmonary tissues, and that asbestos dust is unique among the silicates in the prevalence and severity of the disease that it produces." Cooke[2] is credited with having established asbestosis as a disease entity.

PHYSIOLOGICAL CONSIDERATIONS

The mechanism by which the respiratory organs defend themselves against the toxic or irritative action of dust in the air has been described by Pendergrass.[18] Particles of greater size are excluded from the lungs by being collected upon the walls of the upper air passages from which they are later expelled by efferent air currents and by ciliary action. Particles not larger than one micron in diameter may reach the alveoli, become engulfed by macrophages, pass through the alveolar walls and along the interstitial lymphatic systems to pulmonary lymphoid deposits, to tracheobronchial and hilar nodes, and into the general circulation. Lymph flow may reach the hilum by way of the superficial (pleural) lymphatic system if the deep lymphatics become obstructed, and such flow is facilitated by the respiratory motion of the diaphragm and chest wall and by the massaging effect of the ribs. The collection of dust in the intercostal spaces of the pleura is attributed to massaging action and is believed to explain a curious manifestation seen at postmortem examination in one of the cases herin reported. Tissue changes found in the lungs and pleurae are due to the presence of dust or its transition, and constitute the response to either toxic or mechanical injury.

CONCERNING ASBESTOSIS

Gloyne[10] describes gross tissue changes in asbestosis as involving both the lungs and the pleurae. The visceral pleura is thickened and there are extensive sessile adhesions that may close all or part of the pleural sac and obliterate the interlobar fissures. In advanced cases, horn-like plaques may form on the parietal pleura. The lungs do not collapse when the chest is opened but are heavy and gritty on section. Emphysematous bullae are commonly found at the apices and along the free borders. The primary cellular response is the mobilization of macrophages and fibroblasts. Around the distal portions of the bronchial

* From A. Barton Hepburn Hospital, Ogdensburg, New York.

tree and around the alveoli, a fine network of collagenous fibrous tissue is formed ultimately producing a generalized reticular fibrosis which is a distinguishing feature of the disease. Poorly formed foreign body giant cells are found and pleuropericardial adhesions occur. Gardner[6] explains that in the case of free silica, the crystalline form when acted upon by tissue juices becomes the colloid capable of causing fibrous tissue proliferation as a response to toxicity. In contradistinction, the asbestos fiber acts mechanically to produce fibrosis with respiratory motion being an accentuating factor. Although the minute particles of free silica may reach the alveoli and thence find their way into the peribronchial lymphoid tissue, the asbestos fiber comes to rest in the respiratory bronchiole or alveolus and there, through its irritating propensities, produces a fibrous collar which ultimately undergoes collagenous degeneration. Along with the tissue changes there is also found histopathologically the asbestosis body, which, according to Gloyne,[10] is pathognomonic of the disease. These are yellow-brown rods produced by the heavy coating of iron and organic material upon asbestos fibers. They may have bulbous or pointed ends, do not take the usual vital stains, and the coating layer is soluble in strong inorganic acids. These bodies are probably formed by colloidal interaction of the fiber with blood proteins. Gardner[6] considers that the asbestosis body constitutes a tissue reaction not entirely compatible with the hypothesis of purely mechanical stimulation of fibrosis in the lung. According to Wood and Gloyne,[24] it is not to be confused with any other substance in human histology. It may be found in great numbers in the lungs; its appearance in the sputum is an indication of unfavorable prognosis.

Pendergrass[17] describes the early roentgenographic evidence of asbestosis as a faint homogeneous haziness in the lower half or two-thirds of the mid-lung fields which may cause the trunk shadows to become less well defined. This ground glass appearance may later resolve itself into fine mottling and into fine linear shadows so arranged as to resemble cobwebs. These lesions progress directly to diffuse massive fibrosis with little evidence of an intermediate nodular stage. Bilateral symmetry may not be maintained. Roentgenoscopically the descent of the diaphragm and costal expansion may be found to be limited, and when this occurs, progress of the disease is apt to become accelerated. The visceral pleura, seen in profile, may be thick; pleural adhesions may be extensive and costophrenic sulci obliterated. As the disease progresses, successive films demonstrate shortening of the vertical diameter of the chest. In late stages there are massive conglomerate lung field shadows that obscure the leaves of the diaphragm and borders of the heart.

Sayers and Lanza[21] observe that "whereas the roentgenogram may show considerable involvement in silicosis with few if any symptoms, the reverse is apt to be true in asbestosis."

Cardinal symptoms are dyspnea and cough.[24] Cough is usually dry or productive of viscid mucus, or the sputum may be blood streaked. There is invariably dyspnea on slight exertion; weight loss and lassitude are common; tightness in the chest is often a most distressing symptom. Anorexia is an unfavorable prognostic indication. Objectively there is usually slight cyanosis, clubbing of the fingers, reduced chest expansion and reduced vital capacity. Whether or not the disease progresses after withdrawal from exposure is a controversial question, as is also the prevalence of complicating tuberculosis. The observations of Haddow[11] that symptoms are generally more severe during the winter months and particularly after acute colds, suggests that nonspecific infection may play an important part in clinical progress.

There seems to be more than a casual relationship between asbestosis and bronchogenic carcinoma. Gloyne[8,9] has found the two conditions concurrent in 3 cases examined at autopsy. Linzbach and Wedler[14] report another such case and summarize those previously reported from

sources in England and Germany, comprising a total of 12 cases. The German authors suggest that mechanical irritation may be a cause of the complication but they also offer the hypothesis that silicic acid present in the interstitial pulmonary tissues may be responsible, and they refer to the experimental work of Siegmund[23] as evidence of the carcinogenic properties of silicic acid. Holeb and Angrist[13] contribute 2 more cases, having found bronchogenic carcinoma in the only 2 cases of asbestosis that they have seen at autopsy. It would appear that the incidence is very much higher in persons with asbestosis than in a general population of otherwise similar circumstance.

CONCERNING TALC

The industry to be considered herein as providing a cause of pneumoconiosis comprises talc mining and milling operations in northern New York. It has twice been comprehensively surveyed, and the two surveys are in essential agreement as to the physical conditions to which laborers are subjected. Dreessen,[4] about 1932, found that, at breathing levels in various situations, the concentration of very fine dust was many times that specified by Sayers and Lanza[21] as being minimal for the production of both silicosis and asbestosis. Sixty per cent of the dust was hydrous magnesium silicate (talc) occurring in equal proportions as tremolite and soapstone. No free silica was found. Siegal, Smith and Greenburg[22] in 1940 and 1941 confirmed the composition and concentration of the dust, confirming also the fact that free silica was not present in any significant amount. These authors describe and pictorially illustrate the morphologic similarity between the fibers of talc and those of asbestos. The two surveys did not exactly support each other in respect to the incidence and severity of pneumoconiosis. Dreessen detected roentgenographically a high incidence of pulmonary fibrosis none of which he considered to be of sufficient extent to be disabling. It should be noted that Dreessen and DallaValle[5] did find disabling pneumoconiosis where a different form of talc was being mined in Georgia. The latter New York investigators record 14.5 per cent of miners and millers as having advanced fibrosis, which would indicate that no improvement had been effected in mine hygiene in the intervening nine years. At a time coincident with the investigations of Siegal, Smith and Greenburg, we[19] were able to demonstrate by clinical and postmortem studies that talc is capable of causing pulmonary fibrosis unlike that of silicosis, that such changes may be disabling and may by themselves cause death. The reports of the mine surveys and our previous observations would seem to qualify the occupational hazard. The following observations have to do with patients rather than industrial employees. All of the persons considered were in some measure disabled when first seen, many entirely so for hard manual labor. The fact that one member of the group has continued to perform hard labor until recently is believed to be an indication of poor judgment rather than of good health.

CLINICAL MATERIAL

Observations have been continued on 7 of 15 cases reported in 1942.[19] At that time 4 of the 7 were listed as being disabled for any gainful employment, and during the four year period, 2 of these have died of respiratory disease, while 2 others continue to be disabled with little apparent change. Three cases, then able to do light work, are still so employed but 2 of them are at lower levels of physical capacity.

During the same four year period, 6 other cases in whom talc pneumoconiosis has been diagnosed, have been seen in the A. Barton Hepburn Hospital. In none of this group was pneumoconiosis the cause of admission, though all had clinical indications of it. Two were admitted for gastrointestinal survey because their chief complaints were anorexia and loss of weight. In neither case was a gastrointestinal lesion found while both had roentgen evidence of

extensive pulmonary fibrosis (Fig. 9). Both subsequently died at home and postmortem examination was not done. Two of the group died in the hospital and in each case the diagnosis of pneumoconiosis was anatomically confirmed. Two survivors of the group are regularly employed at light work which is the limitation imposed by loss of physical stamina.

The estimation of physical disability is based upon physical determinations rather than upon roentgenographic interpretation. Respiratory function is estimated by measuring chest expansion and vital capacity. These factors are somewhat variable in healthy individuals according to age, sex, habitus and indulgence in athletic sports. A number of healthy males in a comparative age group were examined and none were found to have chest expansion of less than 2½ inches, nor vital capacity less than 3.3 liters. Neither the Schneider test of circulatory efficiency nor the ergometric test described by Hannon[12] were found to be applicable for the reason that in those least ill, exercise insufficient to bring about either marked or sustained elevation of pulse rate would cause distressing dyspnea. In 5 of the 6 patients who died, at no time during the period of observation was exercise permissible. The 4 cases that are selected for more detailed individual report are believed to be examples of the type of pneumoconiosis, and 1 case also records concurrent pulmonary neoplasm.

CASE REPORTS

Case 1. I.S., aged forty-six. Prior to becoming partly disabled, the only occupation in which this patient had ever engaged was talc mining, which was begun at the age of seventeen and continued until the age of forty-one. During the first eight years when he operated a pneumatic drill, the work was very dusty. This was followed by a period of non-dusty work and then during a period of nine years as mine superintendent he was sometimes exposed to heavy dust concentrations.

In June, 1940, he had a respiratory infection considered to be influenza. Soon thereafter he became short of breath and during the succeeding year lost weight. At times he had a nonproductive cough; fever was not observed. In June, 1941, he quit work in the mines and since that time has usually been employed as a carpenter repair man. Some lost weight has been regained.

Fig. 1. Case 1. Pneumoconiosis (talc). The hila are dense, the lower lung fields are hazy with soft nodulation. There is partial clinical disability with progression after withdrawal from exposure.

When examined in October, 1941, rales and rhonchi were heard, fingers and toes were clubbed, there was slight cyanosis, chest expansion was 2 inches and vital capacity was 3.1 liters. The chest film of the same date Fig. 1) demonstrates diffuse bilateral symmetrical haziness in the region of the lower lobe trunk shadows and soft nodulation in the peripheral zones. Lower lobe trunk shadows are dense but indistinct and part of the profile of the heart is indistinct.

During the subsequent four years, this patient has been free from concurrent illness except that he has had mild respiratory infection on a few occasions and these have only temporarily increased his dyspnea. Shortness of breath in some degree has been constant and he has usually had a dry cough. On January 8, 1946, respiration was effortless while at rest, but became labored after very slight exertion. Cyanosis and clubbing of the fingers were again noted. Chest expansion continued to be 2

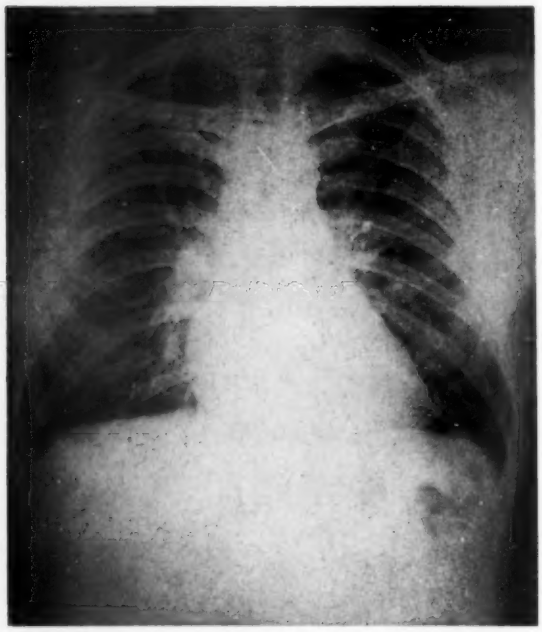

Fig. 2. Case II, 1942. Prominent hila and soft beading of lower lobe trunk shadows are insignificant evidence of disease. Clinically there is evidence of slight respiratory disability.

inches; vital capacity had become reduced to 2.7 liters. A roentgenogram of the chest showed no significant change when compared with that of October, 1941. On roentgenoscopic examination, the limit of diaphragmatic excursion was 2 cm. on both sides.

Case II. Wm. S., aged forty-one. The only history of occupational exposure to dust has been that of mucker in talc mines for sixteen years, extending over a period of twenty years. There is no history of serious illness since childhood but during recent years he has been subject to acute colds. Since March, 1940, he has been easily fatigued, has been short of breath, has had an irritating cough and at times a subjective feeling of tightness in the chest.

When first examined, March 4, 1942, he weighed 134 pounds and was 65 inches in height. Clubbed fingers and mild cyanosis were observed; no rales were heard. Chest expansion measured 2 inches and vital capacity 2.4 liters. A chest film (Fig. 2) demonstrates nothing significant except heavy hilum and trunk shadows and soft beading in the lower lobe trunks.

On November 8, 1942, he was accepted for military service, was never on sick report and was discharged seven months later by reason of being over age. He then returned to work in the talc mines, being employed as a mucker until October, 1945, at which time he was obliged to quit because hard labor aggravated his symptoms of dyspnea and tightness in the chest.

When examined on January 11, 1946, he complained of poor appetite, rheumatism of the hands and right shoulder and of the symptoms previously noted. Body weight was reduced to 125 pounds, chest expansion to 1 inch and vital capacity to 1 liter. Other observations were like those of March, 1942. In the roentgenogram (Fig. 3) there is a soft nodulation in the lower left lung field that was not present four years previously. Roentgenoscopically, the limit of respiratory excursion of the right leaf of the diaphragm was 1.5 cm., and the left leaf was immobile.

Case III. Wm. M. The occupational history included seventeen years of exposure to highly concentrated dust in talc mines as driller and mucker. This, his only dusty occupation, was begun at the age of nineteen and continued until he became totally disabled at the age of thirty-seven.

When first seen in June, 1941, he complained

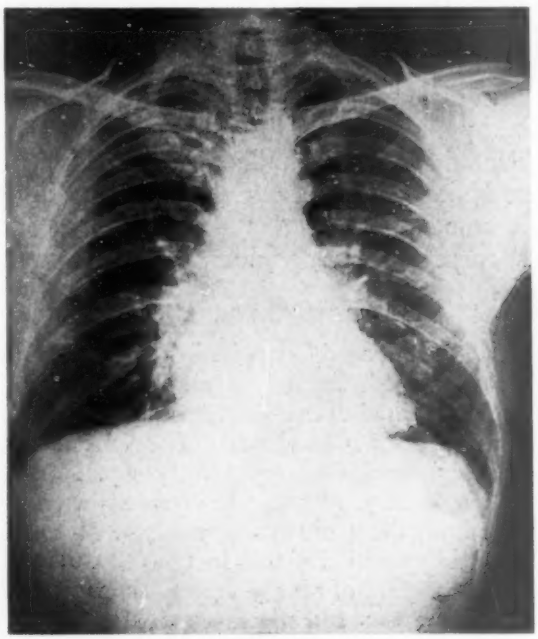

Fig. 3. Case II, 1946. The hila are larger and denser and soft nodulation in the left lower lung field is more extensive. Clinically there is moderate disability.

of dyspnea, dry cough and easy fatigability. He had then been unable to work for two years. He was well nourished, was slightly cyanotic, and had clubbed fingers and a vital capacity of 2.8 liters. The chest roentgenogram (Fig. 4) demonstrates soft, indistinct, dense nodules bilaterally in the mid-lung fields with nodules becoming confluent on the left and in the right peripheral zone. Radiolucence, characteristic of emphysema, is seen at the bases and there are tented distortions of both leaves of the diaphragm.

During the summer of 1942 he was committed to the St. Lawrence State Hospital because of general paresis. A routine chest film made October 3, 1942, showed little change when compared with that of the previous year. On June 6, 1943, there was appreciably greater confluence of lesions having similar distribution. A clinical note of November 12, 1943, records for the first time a poor state of nutrition. During July and September, 1944, there were mildly febrile episodes and further extension of dense pulmonary lesions was found in the roentgenogram of July 10. A final chest film (Fig. 5) was made September 11, 1944, and shows massive dense lesions involving all of the right lung except the emphysematous base, and the left mid-lung field with emphysema at the base and apex. Beginning in October, 1944, dyspnea, cough and cyanosis became increasingly severe; terminally there was ascites and dependent edema. Except as noted, there is no record of fever, and tubercle bacilli were not found in the sputum. Death occurred on December 30, 1944, the patient being at that time forty-two years old. Postmortem examination was not done. The recorded diagnoses were paresis, pneumoconiosis and tuberculosis.

Fig. 4. Case III, 1942. Moderately advanced pneumoconiosis (talc). Many lesions are coalescent, there is emphysema and adhesive pleurisy. Clinical disability is complete.

Fig. 5. Case III. 1944. Far advanced pneumoconiosis (talc). There are massive dense lesions and emphysema with asymmetrical development.

Case IV. F. V., aged sixty-four. The occupational history includes about twenty years in talc mining, not all of which was dusty work. At the time of admission to the hospital, June 18, 1945, he had not been so exposed for several years.

Upon admission, the patient complained of back pain which had been initiated suddenly four months previously while lifting a heavy object, and which since that time had been nearly continuous and moderately severe. Admission temperature was 100° F. and there was a mild leukocytosis. On June 23, a surgical operation was performed for the removal of extruded nuclear material from two mid-dorsal intervertebral discs. In a chest film of July 7,

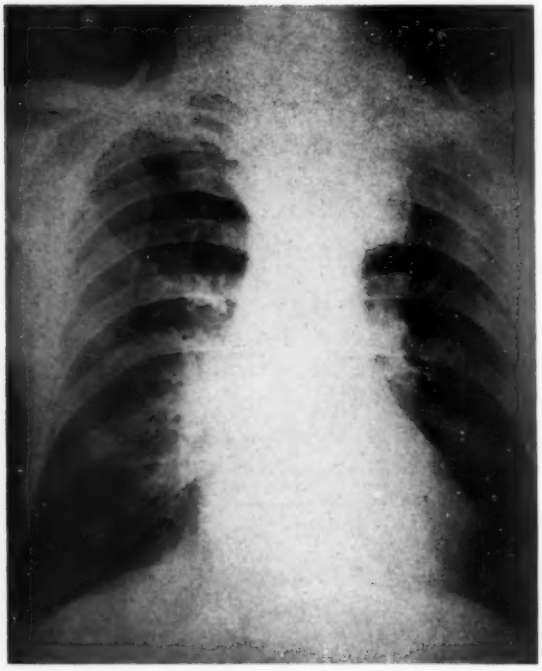

Fig. 6. Case iv. Pneumoconiosis (talc). Diffuse fine reticulation. The dense mass in the left apex is bronchogenic carcinoma.

there was demonstrated a bilaterally symmetrical fine reticulation involving all of the lung fields except the apices and bases. There was a poorly defined dense area in the median zone of the left apex. The abnormal shadows were interpreted as evidence of pneumoconiosis with confluent lesions in the left apex. A slight fever was maintained throughout the period of hospitalization. The patient was discharged on July 12 but was re-admitted on July 24 for four days for injection of intercostal nerves.

Fig. 7. Case iv. Section from the apex of the left lung (×240). There are proliferating connective tissue (1), loosely arranged tumor cells (2) and an asbestosis body (3).

Back pain was again the cause of admission on October 19. At this time a history was obtained of a mild, long standing dyspnea, and slight clubbing of the fingers was observed. The chest roentgenogram of October 19 (Fig. 6) is much like that of July 7 except that the dense shadow in the left apex has become larger and more sharply defined and osteolytic areas are found in the dorsal segments of the third and fourth ribs. Mass lesion of the lung was an additional diagnosis based upon roentgenographic evidence. On October 31, part of the lung tumor was surgically removed. It had invaded the chest wall and adjacent vertebral bodies to such an extent that complete removal was not possible. There was distressing dyspnea after this operation and the patient died on November 15, 1945.

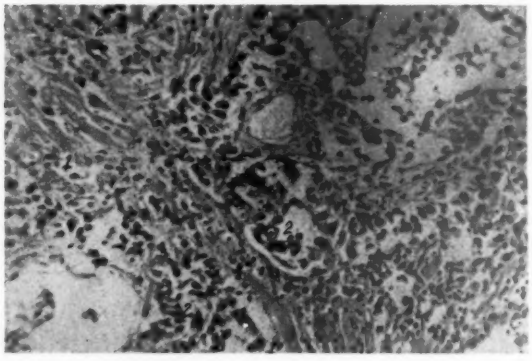

Fig. 8. Case iv. Section from the apex of the left lung (×240). There are connective tissue proliferation and fibroblasts (1) and tumor cells with alveolar arrangement (2).

At autopsy, the pleurae were relatively free with only scattered adhesive bands except in the vicinity of the recent operative field where the pleural space was obliterated and there was a draining sinus tract. There were thick, irregular, yellow bands of rubbery consistency occupying intercostal spaces on the parietal pleura of both sides. The lungs were heavy, tough and gritty on section; there was a residual tumor mass in the left apex, adherent in the paravertebral gutter, with invasion of the body of the third dorsal vertebra. Dorsal segments of the second, third and fourth ribs had been removed. The following report of microscopic study of tissue in this case is furnished by Porro,[20] whose diagnosis is pneumoconiosis and bronchogenic carcinoma.

The alveoli adjacent to the pleura are atelectatic while more central alveoli are emphysematous. In many alveoli there are numerous asbestosis bodies associated with a brown debris and macrophages laden with similar material. There are occasional, poorly formed giant cells occurring with asbestosis bodies. In many of the alveolar walls and lobular septa there is a moderate fibrocellular reaction consisting of fibroblasts, loosely arranged connective tissue, bands of collagen, particles of pigment and a few macrophages and lymphocytes. In some adjacent alveoli there is metaplasia of epithelium as is commonly seen in fibrosing disease of the lung. Lymphoid nodules along the septa are hyperplastic but do not contain asbestosis bodies. The pleura adjacent to the tumor is thickened by scar tissue.

The tumor consists of irregular strands and masses of cells having alveolar arrangement, and of single epithelial cells of various shapes, cuboidal, polyhedral, oval, spindle and stellate. The background is collagen and fibroblasts. Asbestosis bodies are not found in the tumor mass, but one such body is found with loosely arranged tumor cells in a tissue space adjacent to the main tumor mass.

The general pulmonary cellular reaction is like that of other cases of talc pneumoconiosis seen at autopsy. The cellular pleomorphism of the tumor is common in bronchogenic carcinoma.

COMMENT

The principal clinical indications of talc pneumoconiosis, dyspnea, cough, cyanosis, clubbed fingers and diminished vital capacity, are common to all types of disabling pneumoconiosis. The specific relation to asbestosis is remarkable when the clinical picture is correlated with roentgen findings. The early roentgenographic manifestation in either disease is lung field haziness, fine reticulation or soft nodulation, which may be so delicate as to escape detection. It is quite unlike the distinct nodulation typical of silicosis. As disease progresses, the parenchymal pulmonary lesions gradually become denser and tend to become confluent, developing asymmetrically with compensatory emphysema, without nodulation and with a predilection for pleural involvement. Such roentgen changes observed in talc

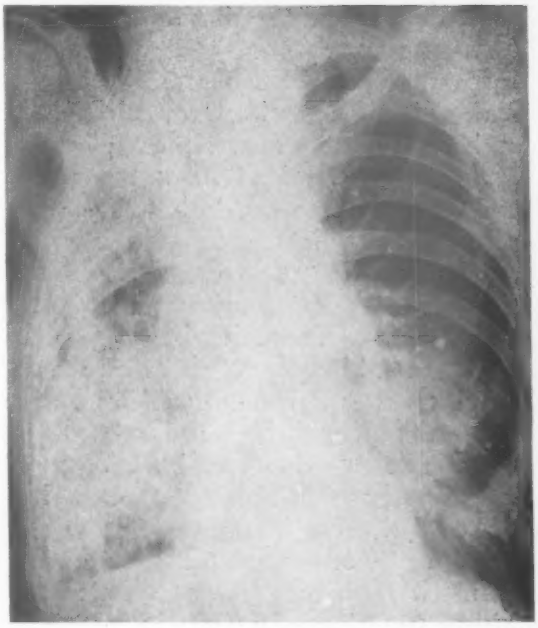

Fig. 9. Case of advanced pneumoconiosis (talc) showing asymmetry of development. Although dyspneic, the patient was most concerned about anorexia and loss of weight.

pneumoconiosis have also been described for asbestosis. As clinical indications of unfavorable prognosis, anorexia and weight loss have been noted in both diseases. Pendergrass[17] emphasizes the value of roentgenoscopy in asbestosis because the limitation of respiratory motion is often more informative than the chest film or even a series of chest films. The importance of roentgenoscopy is also recognized in talc pneumoconiosis.

Only Case II of this report has continued to work in dust after having become disabled. He evidently has progressive, though not yet advanced, fibrosis. Progression of asbestosis after withdrawal of the worker from exposure is a matter of some disagreement. Case I illustrates a stabilized degree of disability extending over a four year period. He represents 5 cases in a series of 13. Case III progressed rather rapidly to fatal termination as did 2 others of the series. All were diagnosed as having complicating infection, either pneumonia or tuberculosis, but in none of the 3 was the diagnosis confirmed by autopsy or

laboratory studies. The diagnosis of tuberculosis in such case may be questioned. Dayman[3] reported his observations on a large series of silicotics, many of whom had the presence or absence of complicating tuberculosis determined at autopsy. He found that when tuberculosis was present to a significant degree, its characteristic symptoms dominated the clinical picture, and in almost every instance tubercle bacilli had been found in the sputum. It has been noted in some of these cases that there is a susceptibility to colds and that the sequelae of such illness may be disastrous. Similar observations have been recorded for asbestosis. Hence it appears that while complicating infection may be the frequent cause of progressive disease, such infection is not necessarily tuberculosis.

The recognition of a single instance in which bronchogenic carcinoma develops upon talc pneumoconiosis is not in itself of statistical value, but it does tend to bind the disease more closely to asbestosis as a clinical entity. It is possible that there have been other such occurrences inasmuch as the proportion of autopsied cases to the total number of talc pneumoconiosis cases now dead is believed to be small.

The prevention of pneumoconiosis continues to be an important local problem. Whatever measures may have been instituted seem to be not yet very effective. The maximum limit of compensability for total and permanent disability has been legally increased in New York, but has probably not served to lessen incidence. It has been reported that some mines have changed methods of operation from dry to wet process which may prove to be advantageous. Improvement of hygienic conditions in the mines and mills seems to be most desirable. Closer medical supervision has been instituted in part, for the purpose of withdrawing men from exposure before they become disabled. With such measures, an alert medical examiner can become quite effective.

SUMMARY

Literature concerning silicate produced pneumoconiosis has been reviewed. Selected cases of pneumoconiosis of talc workers have been reported and the composite findings compared with those recorded for asbestosis. Prophylactic measures have been briefly discussed.

CONCLUSION

1. Talc pneumoconiosis and asbestosis are remarkably similar.
2. Tissue reaction may be partly due to chemical cause.
3. It is possible for early disease processes to become arrested, but they are apt to become progressive as the result of infection. There is no recovery from established disability.

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GIANT BULLOUS EMPHYSEMA PRODUCING CLOSURE OF A TUBERCULOUS CAVITY*

A CASE REPORT

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ALTHOUGH there are several authoritative reports dealing with the general problem of pulmonary emphysema in pulmonary tuberculosis, only the recent comprehensive work of Guggenheim[2] deals in any detail with the association of bullous emphysema with pulmonary tuberculosis. The phenomenon of a giant bulla acting in much the same fashion as an artificial pneumothorax in producing closure of a tuberculous cavity has been reported on only one occasion. In 1938, Dobric[1] described the case of a male, aged thirty-three, whose chest roentgenogram following an attack of hemoptysis revealed a tuberculous cavity involving the left upper lobe. The sputum was positive for tubercle bacilli. Following therapy with gold, as well as the routine sanatorium regimen, the patient's condition showed a marked improvement. A chest film taken several months following the original study revealed complete disappearance of the cavity and its replacement by giant bullous emphysema. At this time, sputa and gastric washings were negative for tubercle bacilli.

Because of the infrequency with which such a phenomenon is observed, and because such a case has not hitherto been described in the American literature, the following case is being reported.

CASE REPORT

A white male, aged fifty-six, was admitted to Veterans Administration Hospital, Fort Logan, Colorado, on July 2, 1947, complaining of anorexia and generalized weakness of two years' duration.

The past history included an episode of migratory polyarthritis in 1922.

System review was negative except for mild exertional dyspnea. The diagnosis of pulmonary tuberculosis was first established in 1919 when the patient was hospitalized in a North Carolina sanatorium following a pulmonary hemorrhage. Sputum examinations were positive for acid-fast bacilli. He remained in the sanatorium for only three months and from this time until 1922 he was hospitalized in several institutions. Throughout this period, sputum examinations were repeatedly positive for acid-fast bacilli. From 1922 until the present time, the patient was followed on an out-patient status. His disease was considered active until 1942 when his classification was changed to "quiescent."

On admission to this hospital, the patient stated that cough was infrequent and productive of approximately one tablespoonful of mucopurulent sputum daily. He also complained of an intermittent wheeze which was localized to the left upper anterior chest.

Physical Examination. Temperature, 98.6° F.; pulse, 86; respirations, 20; blood pressure, 120/70. The patient was a well developed and well nourished white male in no acute distress. There was no icterus, cyanosis, dyspnea, or clubbing of the fingers. Examination of the head and neck revealed no abnormalities. The pupils were equal, regular, and reacted to light. Funduscopic examination was normal. Ear, nose and throat examination was negative. Examination of the chest revealed the respiratory excursions to be equal and symmetrical. Slight dullness and diminished breath sounds were noted over the upper half of the left chest anteriorly and posteriorly. A moderate number of medium moist rales was heard over the left posterior apex. No wheeze was detected. The remainder of the lung fields was clear. The heart was not enlarged, rhythm was regular and no murmurs or thrills were observed. Abdominal examination revealed no

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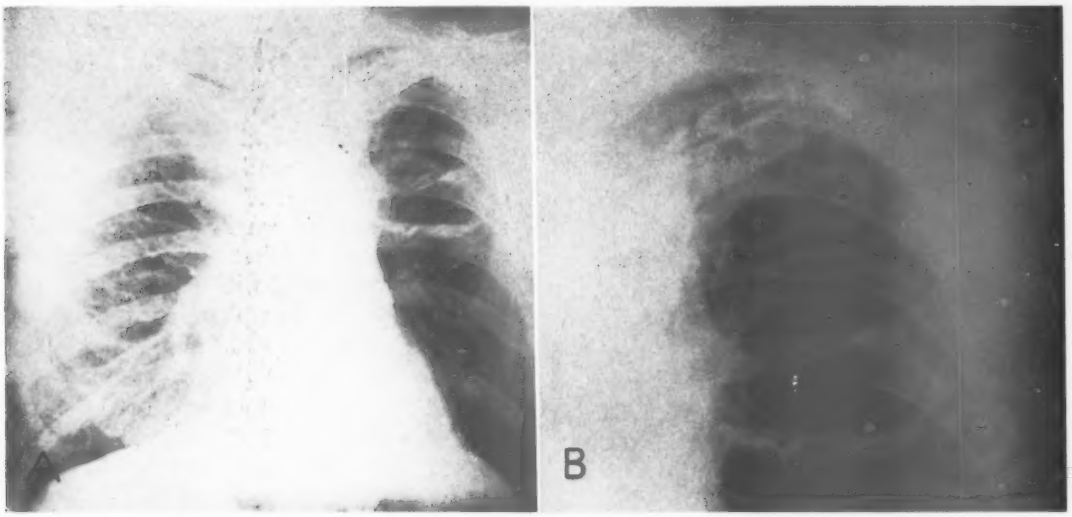

Fig. 1. (*A*) Posteroanterior chest roentgenogram, August, 1925, which reveals the giant bulla occupying the upper half of the left lung field. A fluid level in the bulla is visible. The tuberculous cavity is seen within the circle of the left first rib. (*B*) Enlargement of the preceding roentgenogram, which illustrates the loculated character of the giant bulla and the close association with the tuberculous cavity within the circle of the left first rib.

abnormalities; the liver, spleen and kidneys were not palpable. Rectal examination was negative; the prostate gland was normal in size, shape and consistency. Neurological examination was grossly normal. No lymphadenopathy was noted.

Laboratory Data. Red blood cell count, 5.12 million; hemoglobin, 15.5 gm.; white blood cell count, 8,200; neutrophils, 60; lymphocytes, 39; eosinophils, 1; urinalysis, negative; blood Kahn reaction, negative. Sputum culture revealed non-hemolytic *Staphylococcus aureus* (mannitol and coagulase negative); *Streptococcus viridans*, non-hemolytic streptococcus and *N. catarrhalis*. Eight sputum specimens were negative for tubercle bacilli on concentrated smear and culture.

Admission chest roentgenogram on July 2, 1947, revealed a large 5 by 7 cm. thin-walled annular hyperlucent area on the left, extending from the apex down to the fourth anterior rib and from the mediastinum almost to the lateral chest wall. Several interlacing strands were observed in this area. At the extreme left apex, numerous small fibrocalcific nodules were noted. Apical lordotic films added no further information, but the lateral projection demonstrated the hyperlucent area to be situated posteriorly. Fortunately, it was possible to obtain several of the patient's old roentgenograms. The first film of the series in August, 1925 (Fig. 1) revealed a large bulla occupying the upper third of the left lung, with a fluid level at the plane of the seventh posterior rib. Of greater interest, however, was the presence of a 2 cm., fairly thick-walled cavity within the circle of the first rib. The second film of the series in July, 1933 (Fig. 2) revealed that the previously noted cavity had disappeared; the bulla was somewhat larger and appeared to be under tension. The fluid level was no longer present. Subse-

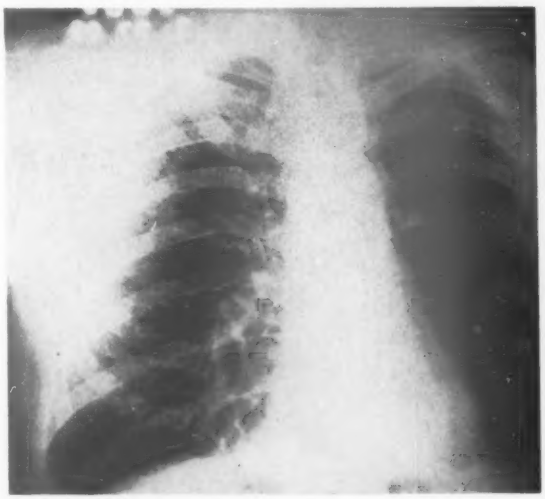

Fig. 2. Posteroanterior chest roentgenogram, July, 1933. The tuberculous cavity at the left apex has disappeared. The fluid level is no longer present.

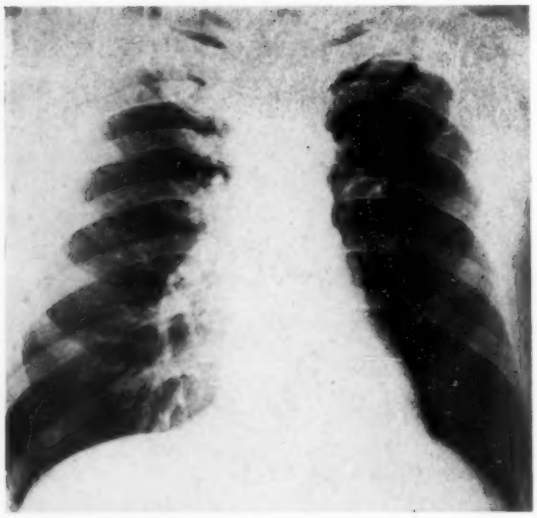

Fig. 3. Posteroanterior chest roentgenogram, July, 1947. There has been practically no change in the appearance of the bulla since the preceding film

quent films (1940, 1942, 1946), including the present film (Fig. 3), show little change from the 1933 roentgenogram.

Bronchoscopy was performed on July 28, 1947. The trachea and carina were deviated slightly to the right. The carina was sharp. The right bronchial tree was normal. The left bronchial tree exhibited pale scarring, which extended from the level of the left upper lobe orifice down into the lower lobe bronchus. This did not reduce the caliber of the left bronchus; the orifice of the left upper lobe bronchus was in normal position and was of normal caliber.

Bronchographic studies were also performed on July 28 (Fig. 4, *A* and *B*). These studies revealed that an area in the left upper lobe extending from the first to the fourth anterior rib was not well filled with the contrast medium and appeared to be emphysematous. The apical branch of the left upper lobe bronchus exhibited marked dilatation in its terminal bronchioles. The subapical branch was seen to bend sharply at its origin extending posteriorly and medially. As it progressed toward the spine, its caliber increased from 3 mm. to over 1 cm. In addition, step-like sacculations producing a ladder pattern could be seen along its entire course.

DISCUSSION

The development of pulmonary emphysema in tuberculosis has recently been reviewed by Guggenheim.[2] He notes that in the majority of instances the emphysematous changes are localized to the immediate vicinity of the tuberculous lesions. The following types of emphysema are described: (1) intrafocal, (2) perifocal, (3)

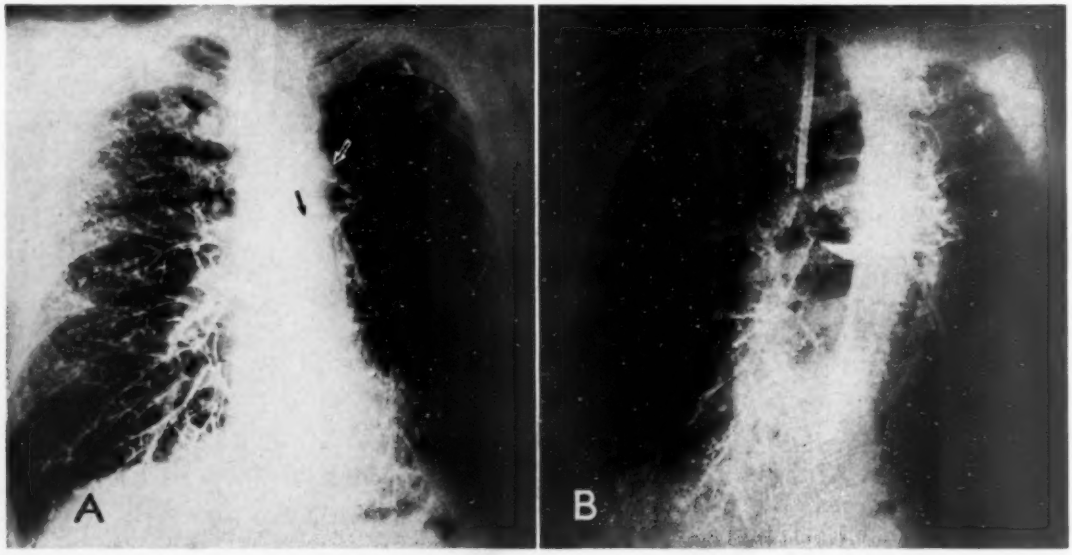

Fig. 4. (*A*) Posteroanterior bronchogram, July, 1947. The upper half of the left lung field is not well filled with the iodized oil. The subapical branch bronchus is seen to bend sharply toward the midline. In addition, the pooling of oil in the retracted left upper lobe bronchus is faintly visible. (*B*) Bronchogram, left anterior oblique view, July, 1947. The course of the subapical branch bronchus is more clearly visible on this film, as is the pooling of oil in the retracted left upper lobe bronchus. The step-like sacculations of the subapical branch bronchus are also more evident on this film.

emphysematous bullae and blebs, (4) interstitial emphysema and (5) diffuse (compensatory) emphysema. He emphasizes the fact that bullae remain unchanged or show insignificant changes in size and shape over long periods of time. This opinion is confirmed by the present case in which relatively little alteration occurred in the size of the bulla over a period of twenty-two years.

The mechanism whereby such bullae develop merits some discussion. It is probable that the entering bronchioli have become narrowed as a result of involvement by some disease process—in this case, tuberculosis. With the development of a check-valve mechanism, air is able to enter the structure during inspiration, but cannot escape during expiration. The accumulation of this trapped air produces the giant bulla. It would follow that such a collection of air would be under considerable pressure. That such is indeed the case is demonstrated by manometric pressure readings of bullae in a postmortem lung. These revealed high positive pressures, plus 8 and plus 11 cm. of water.[2]

With the knowledge that giant bullae may attain positive pressures as high as plus 11 cm. of water, an explanation of the phenomenon witnessed in this case immediately presents itself. If a giant bulla is so fortuitously placed in relationship to a segment of lung containing a tuberculous cavity that it is able to exert its pressure effect maximally upon the segment, then its ultimate effect would be that of a positive pressure pneumothorax. It should be noted, however, that such a result is produced by actual compression of lung tissue. In this respect, the mechanism differs from that of the ordinary therapeutic pneumothorax in which negative intrapleural pressures are constantly maintained and where the effect is one of relaxation of lung tissue rather than compression.

The bizarre bronchographic pattern is also of interest. It is extremely doubtful whether bronchiectasis of lobar or segmental distribution is ever produced by actual tuberculous destruction of the smaller bronchi or bronchioli. A more likely concept is the production of bronchial obstruction by a tuberculous process (granulation tissue) or the residua of such a process (fibrotic stenosis) which, in turn, is followed by a nonspecific pneumonitis distal to the obstruction. Such infections due to secondary invaders are often highly necrotizing in character and may leave bronchiectasis in their wake. The fact that a giant bulla also was present adds further evidence to the conclusion that a bronchial obstructive lesion was responsible for the entire picture in this case.

The peculiar course of the subapical branch bronchus is probably related to the presence of the bulla. The latter displaced the apical segments of the left upper lobe and in so doing produced marked distortion of the draining bronchi.

The treatment in this case was conservative because of the patient's age and the minimal degree of disability produced by the bulla; however, it is recognized that, in those instances where the bulla reaches such proportions as to seriously embarrass pulmonary function, some type of closed suction drainage or even resection of that portion of the lung containing the bulla may be the treatment of choice.

SUMMARY

1. A case of co-existing giant bulla and tuberculous cavity in the same portion of the lung is described.

2. The role played by the giant bulla in producing closure of the tuberculous cavity is discussed.

3. The pathogenesis of giant bullous emphysema in tuberculosis is briefly reviewed.

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AIR INJECTION AS AN AID IN THE DIAGNOSIS OF INTERNAL DERANGEMENTS OF THE KNEE

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PNEUMOARTHROGRAPHY, or air injection of a joint for the purpose of contrast study of the integral cartilaginous, muscular and ligamental structures, has been established as a valuable adjunct in the diagnosis of internal derangements of the knee joint.[1,6,7,8,9,10,11,13,14,15] By permitting a roentgenographic visualization of the normal and abnormal internal structures of the joint cavity, this method furnishes significant information in the analysis of those cases which, either because of insufficient history or inadequate physical findings, would ordinarily be classified as clinically inconclusive. For example, Hauch[6] reports 21 clinically indefinite cases in which no diagnosis could be made clinically. In this group eleven torn menisci were diagnosed on roentgen examination. Seven of these were confirmed surgically. Three were not operated upon, but showed presumptive evidence of tear. One showed hypermobility of the meniscus and no tear. This method is furthermore of practical value in localizing the site of pathology in the clinical syndrome of the "locked knee" which, according to Levinthal[12] may be produced by hypertrophy of the infrapatellar fat pad, by joint mice or by tears of the semilunar cartilages. The procedure frequently supplies additional evidence in testifying to the validity of complaints in certain cases and is helpful in differentiating those cases which will require surgical rather than conservative treatment.

The routine anteroposterior and lateral roentgen examination of the knee furnishes a preliminary survey in the study of internal derangements of this joint. These views demonstrate the articular bony tibiofemoral condyles, the tibiofibular articulation and the patella. The soft tissue shadow of the extensor tendon is observed lying anteriorly and those of the gastrocnemii and hamstring tendons are noted posteriorly. The joint space is occupied by a homogeneous undifferentiated density from which the outlines of the semilunar cartilages cannot usually be identified. The infrapatellar fat pad appears as a radiolucent structure. Unfortunately, however, information as to the status of the semilunar cartilages and the cruciate ligaments, the size and shape of the infrapatellar fat pad, the appearances of the synovia and of the hyaline articular cartilages cannot be obtained at this overall study and a contrast method of examination is necessary for an adequate demonstration of these structures.

The contrast media utilized in pneumoarthrography are of various types. Negative (radiolucent) contrast has been demonstrated by air, oxygen and carbon dioxide. Positive (radiopaque) contrast using abrodil, skiodan, iopax, and lipiodol has been advocated. Combinations of both positive and negative contrast have been described.

Gas contrast has the advantages of being non-irritating and of accurately visualizing the desired structures. It does not lead to the irritation inherent in the opaque media and is absorbed readily. Contraindications are very few. There have been no recorded fatalities. Kleinberg[11] in 1901 reported a case of non-fatal pulmonary embolism following injection by an inexperienced worker. Simon, Hamilton and Farrington[15] quote Oberholzer's series of 1,200 injections with no complications of any sort. Hamilton[7] states, "Thousand of paracenteses are performed daily with no regrettable reactions." He suggests that the procedure is uncalled for in frank ankylosis, in joints showing dense fibrotic adhesions and in hemophilia. Blonek and Wolff[1] state, "The method is safe if care is taken."

The recommended technical procedure is

as follows: The skin is carefully shaved, cleansed with alcohol or ether and painted with tincture of metaphen, 1:500. With the patient supine, the skin at the upper lateral aspect of the patella is infiltrated with 1 per cent novocaine. Infiltration is extended to the subcutaneous tissues and capsule. A number 20 needle is introduced into the cavity. A 50 cc. syringe is attached and air is slowly impressed. About 100 cc. is adequate for injection. The air may remain within the joint for five to ten days.

Anteroposterior, lateral (mediolateral) and posteroanterior stereoscopic views are taken routinely. In addition, oblique views, lateromedial views and comparison film with the opposite side may be taken when indicated. The desirable technique is that which visualizes soft tissue and bone in adequate contrast, demonstrates an ample joint space and allows for fairly consistent results. Screens of Eastman mid-speed type are used. The factors, 50 kv. (peak), 15 ma., distance 30 inches, have proved satisfactory. The anteroposterior and lateral views are obtained in the usual fashion. The posteroanterior view is taken with the patient prone, leg flexed in order to permit the tibia to make a 30 degree angle with the table. The central ray is projected perpendicularly to the tibial tuberosity. This usually entails a shift of 20 degrees towards the feet. The spreading of the joint space allows for much more favorable visualization of the menisci, the cruciate ligaments and the articular cartilages than can possibly be demonstrated in the routine anteroposterior view.

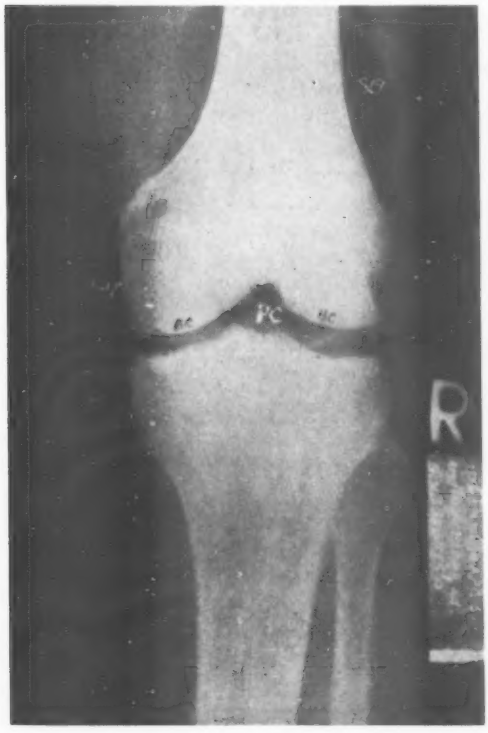

Fig. 1. Normal posteroanterior pneumogram.

Fig. 2. Normal lateral pneumogram.

NORMAL ROENTGEN ANATOMY OF THE KNEE JOINT AS SEEN ON THE PNEUMOROENTGENOGRAM

1. *The Articular Cartilages.* The femorotibial cartilages (Fig. 1) follow the contours of the bony cortices and are about 2 to 3 mm. in width. The cartilage of the posterior patellar surface is a thin layer of the same diameter (Fig. 2). Roentgenologically, the lower border of the femoral articular cartilage is outlined as a curvilinear density, which follows the configuration of the condyles. Medially this linear

shadow overlies the outer two-thirds of the density attributed to the medial meniscus and laterally it overlies the inner third of the shadow of the lateral meniscus in a similar fashion (Fig. 1).

2. *Semilunar Cartilages.* These are two "C" shaped wedge-like structures which deepen the tibial condyles (Fig. 1 and 2). They have a certain mobility and change in size and position with movement of the joint. Their surfaces are covered by synovial membrane. Their peripheral margins are attached to the capsule. The opposite margins are free.

a. Medial meniscus: Anatomically, the anterior horn is attached to the anterior intercondyloid fossa, in front of the anterior cruciate ligament. The posterior horn is attached to the posterior intercondyloid fossa. The transverse ligament reaches from the anterior horn of the medial cartilage to the lateral mensicus. The medial meniscus is adherent to the tibial collateral ligament, and is therefore not as freely mobile as the lateral cartilage. The significance of this will be indicated presently.

Roentgenologically, air injection is seen to sharply infiltrate the upper surface of the meniscus. Kleinberg and Hamilton state that air outlining the lower surface of the meniscus is abnormal. Undoubtedly, infiltration of air below the medial meniscus to a similar or greater extent than is denoted normally for the lateral meniscus is pathological. However, the lower surface may be slightly defined by air contrast and this may be within normal limits (Fig. 1).

b. Lateral meniscus: (Fig. 1) This structure is intimately related to the intercondyloid eminence. The anterior horn arises posterior to the anterior cruciate ligament and the posterior horn is attached in front of the posterior horn of the medial meniscus. The ligament of Wrisberg arises from the posterior horn and sends a slip towards the posterior cruciate ligament to the medial condyle. The meniscus is separated from the fibular collateral ligament by the tendon of the popliteus.

These points are of roentgen importance (Fig. 1). The lateral meniscus is seen normally as a structure of greater mobility than the medial meniscus. It is apparent that a range of mobility which is normal for the lateral meniscus is abnormal for the medial meniscus. Therefore the lateral cartilage will appear well defined both above and below by adequate air contrast. Furthermore infiltration of air within the popliteus bursa, which is continuous with the knee joint, may be reflected on to the lateral cartilage and simulate a tear of this structure. In the lateral view, the anterior pole of the meniscus appears to be continuous with the infrapatellar fat pad anteriorly and with the posterior portion of the articular capsule posteriorly.

3. *Cruciate Ligaments.* (Fig. 1 and 2)

a. Posterior cruciate: This structure is outlined in its greater portion in the postero-anterior view. It arises from the posterior intercondyloid fossa, posteriorly to the medial meniscus and travels upwards and anteriorly to the medial condyle. It is noted roentgenologically as a broad oblique band of density within the intercondyloid fossa.

b. Anterior cruciate: Arises from the anterior intercondyloid fossa between the anterior horns of both menisci and travels posteriorly towards the lateral condyle. These ligaments are strong cords and lie intracapsularly and extrasynovially.

Roentgenologically the anterior cruciate shadow is superimposed upon the lateral border of the posterior cruciate density.

4. *Collateral Ligaments.* (Fig. 1)

a. Tibial collateral: Arises from the medial epicondyle and is inserted into the tibial shaft. This ligament is adherent to the medial meniscus.

b. Fibular collateral: Arises from the lateral epicondyle of the femur and is inserted into the head of the fibula. This ligament is separated from the lateral meniscus by the tendon of the popliteus. The collateral ligaments are noted on the film as homogeneous soft tissue densities, defined by air contrast at their medial borders only.

5. *Infrapatellar Fat Pad.* (Fig. 2)

This structure is triangular in shape in the lateral view. It fills in the anterior tibial condylar space to the anterior capsular wall and the patella. It is extra-articular and extrasynovial. Whereas on the survey roentgenogram this structure appears as an area of radiolucency, on the contrast film it appears as a zone of increased density. Its ligaments are the ligamentum mucosum and the alar folds.

6. *Bursae around the Knee Joint.* (Fig. 1 and 2)

A. *Anterior bursae.*

1. Suprapatellar bursae. Lie between the femur and the quadriceps extensor tendon and the patella.

2. Infrapatellar bursae. Lie between the tibia and the ligamentum patellae at the inferior margin of the fat pad.

These bursae communicate with the knee joint and are normally and adequately outlined on the pneumogram.

3. Prepatellar bursae. These lie between the skin and the ligamentum patellae. They usually fail to be visualized since they do not communicate with the joint.

B. *Posterior bursae.*

These are readily identifiable.

1. Lateral group.

a. Gastrocnemius bursa—Between the lateral head and the capsule.

b. Popliteal bursa—Surrounds the popliteus.

2. Medial group.

a. Gastrocnemius bursa—Between the medial head and the semimembranosus.

b. Semimembranosus bursa—Surrounds its tendon.

3. Other bursae.

a. At the insertion of the tibial collateral ligament.

b. At the insertion of the fibular collateral ligament.

7. *Articular Capsule.* (Fig. 2)

Attached posteriorly to the intercondyloid fossa of the femur and to the tibial condyles. Anteriorly lies the quadriceps tendon and the patella. The ligamentum patellae is related anteriorly and the oblique popliteal ligament is related posteriorly.

The synovial membrane lines the capsule (Fig. 2). It communicates with the suprapatellar and infrapatellar bursae and with the sheath of the popliteus and the gastrocnemius bursae.

ROENTGEN PATHOLOGY OF INTERNAL DERANGEMENT OF THE KNEE JOINT

Pneumoarthography will demonstrate the following conditions:

1. *Tears of the Semilunar Cartilages.* In Levinthal's[12] series of 600 cases, tears of the medial meniscus were found in 41 per cent as compared to 6 per cent for the lateral cartilage. The bucket-handle type was most frequent, appearing in 50 per cent of these medial cartilage tears. Other types of tears listed were: those of the anterior horn, posterior horn, involvement of the middle third of the body, and marginal displacement.

FIG. 3. Tear of the medial semilunar cartilage. (A) Fracture line. (B) Attachment of cartilage to the medial collateral ligament.

Roentgen-Ray Criteria.

(1) Fracture line through the cartilage—may be single (Fig. 3) or multiple. The

FIG. 4. Tear of the medial semilunar cartilage. Note fragmentation suggestive of bucket handle tear.

latter appearance may be seen in the bucket-handle type of tear (Fig. 4).

(2) Gross infiltration of the air column beneath the medial meniscus. The lateral meniscus normally may be raised by infiltration of air column. Elevation of the medial meniscus to the same or greater degree is abnormal.

Confusing Shadows May Simulate a Tear (Fig. 6).

(1) The apron-like appearance of the

Fig. 5. Hypermobility of medial meniscus. Note infiltration of air shadow beneath the meniscus and moderate elevation of cartilage.

overlying femoral cartilage reflected over the body of the meniscus may simulate a fracture line.

(2) Variation of the normal may occur. Comparison with the normal side is indicated in roentgenologically doubtful or inconclusive cases.

(3) The popliteal tendon synovial sheath which communicates with the joint cavity may be reflected over the outer surface of the lateral cartilage and simulate a fracture line across this region.

Case I. (Fig. 3) Patient twisted right knee in athletics October 16, 1944. Complained of pain and "locking" since. November 7, 1944, pneumoarthrogram demonstrated a loss of continuity of the inner portion of the medial meniscus consistent with a tear. Confirmed surgically November 17, 1944. Dr. Ernest Born stated: "Marginal tear of the peripheral aspect of the body. The posterior attachment of the cartilage was partially detached. The lateral posterior lip was separated by $\frac{3}{8}$ inch from the body of the cartilage."

Case II. (Fig. 4) Patient aged twenty-nine. Has had trouble with knee for several years, worse lately. Clinical diagnosis was internal derangement of left knee with old patellar fracture. Pneumoarthrogram August 23, 1944. Inner surface of the medial meniscus is fragmented, suggesting bucket-handle tear. The meniscus is slightly elevated. The patellas are congenitally bifid.

2. *Dislocation of the Meniscus.* As previously indicated, a degree of motion which is considered to be of normal range for the lateral meniscus is abnormal for the medial meniscus. Criteria indicating hypermobility or subluxation of the menisci are: (1) elevation of the cartilage; (2) extensive air infiltration between cartilage and the tibial cartilaginous or bony surfaces.

The following cases demonstrate these features:

Case III. (Fig. 5) This patient dislocated his right knee on September 7, 1944. Clinical examination revealed collateral weakness and cruciate tears. Pneumoarthrogram on September 30 revealed "abnormal elevation of the medial meniscus. Loss of continuity suggestive of tear through this region."

Case IV. (Fig. 6) This patient jumped off a vehicle in August, 1944, and has had an unstable knee since. Clinically there was anterior and posterior cruciate and collateral weakness. Roentgenogram showed moderate subluxation at the knee joint, the femoral condyles displaced medially. The intercondyloid eminence shows evidence of hypertrophic changes. Pneumoarthrogram on November 31 showed an abnormal infiltration of the air column below the medial cartilage. The cartilage is displaced superiorly and its lower border is irregular. These appearances are consistent with tear and displacement of the meniscus.

3. *Postoperative Appearance of the Knee Joint Following Menisectomy.* This is illustrated by the following:

Case v. (Fig. 7) This patient injured right knee in automobile accident in December, 1943. Operated upon December 12. Medial cartilage removed. Bone screw inserted. March 12, 1944, operated on for removal of screw. December 15, 1944, showed relaxation of the lateral collateral and the posterior cruciate ligaments. Pneumoarthrogram showed absence of the normal cartilage density; the medial interosseous space shows an abnormal air shadow overlying the tibial plateau. About 1 cm. of the medial portion of the body of the cartilage can still be demonstrated. There are moderate traumatic arthritic changes noted. The bones of the knee joint are decalcified. There is spurring of the prominences of the intercondyloid eminence.

4. *Injuries to the Cruciate Ligaments.*

Pneumoarthrography may show tears, calcification and hypertrophy of these ligaments. Tear of the anterior cruciate is more frequent than tear of the posterior cruciate ligament.[12] This is illustrated in Case III (Fig. 5) and in Case VIII (Fig. 11).

5. *Lesions of the Infrapatellar Fat Pad.*

The fat pad is frequently a cause of internal derangement.[12] Hypertrophy and calcification may be seen (Fig. 8).

Fig. 6. Partial dislocation at knee joint. Moderate subluxation and tear of medial meniscus. Elevation of lateral meniscus.

6. *Loose Bodies within the Knee Joint.*

These may be due to synovial osteochondromatosis, osteochondritis dissecans, osteoarthritic loose bodies and chip fractures. Although these bodies are readily visualized in routine roentgenograms, their exact relationship to the semilunar cartilages and cruciate ligaments may be determined by the pneumoarthrogram.

The following case is an example.

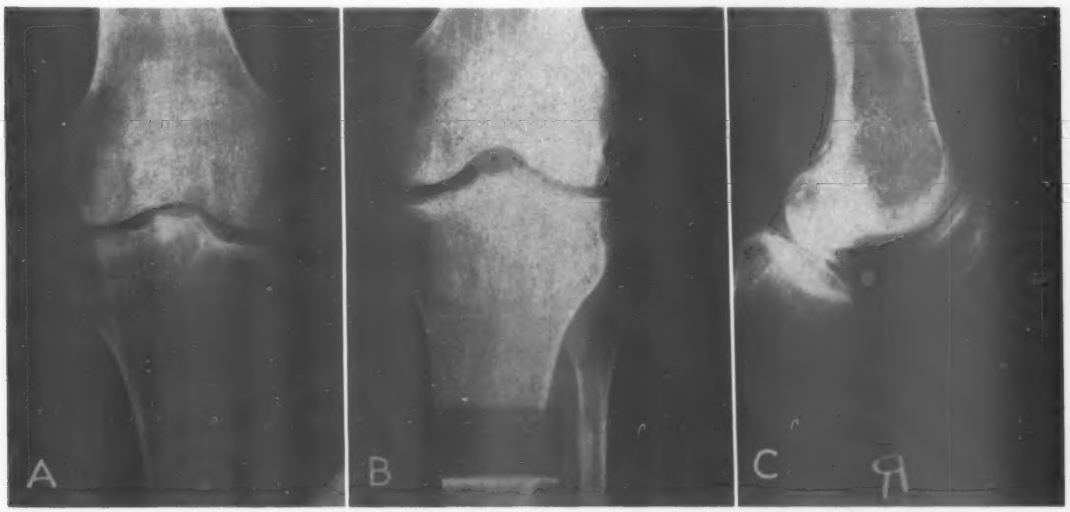

Fig. 7. Appearances following medial menisectomy. (*A*) Anteroposterior view. (*B*) Posteroanterior view. Note an abnormal air shadow overlying the medial joint space. (*C*) Lateral view. Note absence of the normal anterior menisceal density.

Fig. 8. Hypertrophy of the infrapatellar fat pad.

Case vi. (Fig. 9) The flat plate of the knee joint showed a disc-like calcification overlying the lateral tibial condyle. This might be an area of calcification within the lateral meniscus or a synovial loose body. Pneumoarthrogram showed the lateral cartilage to be freely overriding this calcified structure, indicating that the loose body was of synovial origin.

Case vii (Fig. 10) demonstrates the relationship of an area of osteochondritis dissecans to the internal structures of the knee joint. This patient, aged nineteen, had sustained a football injury two years before. Examination revealed relaxation of the collateral ligaments.

7. *Fractures into the Knee Joint.* The extent of injury to the cartilaginous and ligamental structures of the knee may be determined by this procedure.

Case viii. (Fig. 11) Patient injured knee on October 17, 1944, in football practice. Examination revealed an unstable knee; cruciates and collaterals were relaxed. Pneumoarthrogram demonstrates an avulsion fracture of the base of the intercondyloid eminence. The femoral attachment of the cruciates show a loss of continuity suggestive of a tear. An abnormal column of air is deposited below the medial and the lateral menisci suggesting injury to these structures.

8. *Conditions of the Synovia.*

(1) Synovitis—Chronic inflammatory thickening of the synovial membrane is frequently seen.

Case ix. (Fig. 12) Male, aged twenty-four. Original injury in July, 1944. Repeated episodes of locking of left knee joint and recurrent effusion since then. Physical examination revealed moderate effusion and tenderness over medial cartilage. Pneumoarthrogram demonstrated partial obliteration of the suprapatellar bursa by synovial thickening. The semilunar cartilages and cruciate ligaments were of normal appearance. The infrapatellar fat pad was normal.

Case x. (Fig. 13) Chronic synovial thickening obliterating suprapatellar bursa is demonstrated by pneumoarthrography. Patient, aged twenty-five, former athlete, has recurrent episodes of effusion into knee joints. Cruciate and cartilages are intact to physical examination.

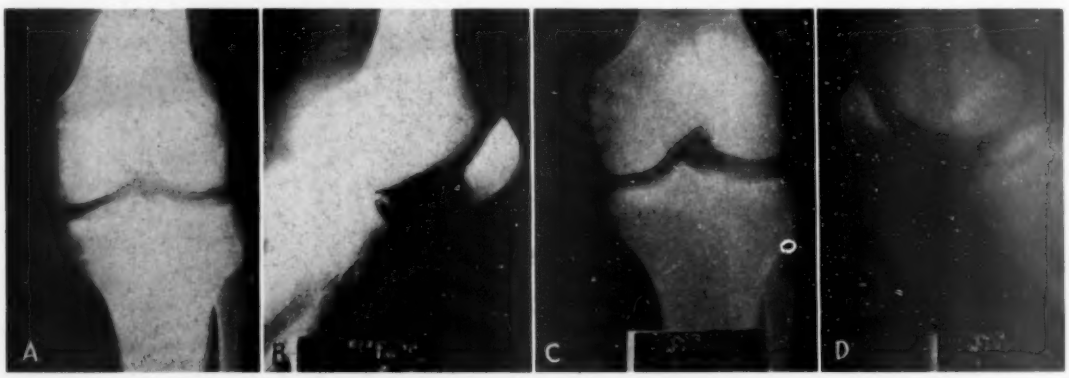

Fig. 9. Synovial osteochondroma. Pneumoarthrogram demonstrates relationship of disc-like calcification to the body of the lateral meniscus. (*A*) and (*B*) Anteroposterior and lateral views of knee joint. Note the calcified structure overlying the lateral tibial condyle. (*C*) and (*D*) Pneumoarthrograms. Lateral cartilage is displaced by synovial calcific density.

FIG. 10. Osteochondritis dissecans: demonstrated in relationship to internal structure of the knee.

(2) Baker's cyst—This is a herniation of the medial gastrocnemius and semimembranosus bursae. The condition is demonstrated by the following case.

CASE XI. (Fig. 14) Male, aged twenty-three. Pain in knee joint at intervals following injury two years ago. On examination there was a cyst-like swelling at the medial aspect of left popliteal space. Relaxation of the posterior cruciate, medial and lateral collateral ligaments were noted.

Pneumoarthrogram showed radiolucent area at posterior aspect of knee joint in relation to head of gastrocnemius and lying directly posterior to the gastrocnemius (medial) bursa. Appearances consistent with hernial protrusion (Baker's cyst). An ununited tibial tubercle is noted. This is attributed to epiphysitis (Osgood-Schlatter's disease). There is mild hypertrophic sharpening of the lateral tibial spine. Mild cruciate thickening is observed. Cartilages are normal in appearance. At operation, Dr. Ernest Born, December 5, 1944, found $1\frac{1}{2}$ by 3 inch hernial cyst overlying the medial head of gastrocnemius.

9. *Localization of Foreign Bodies.* This method may be useful in localizing a metallic foreign body in relation to the soft

FIG. 11. Avulsion fracture of the intercondyloid eminence. Air shadows overlying the cruciate density are suggestive of tear of these ligaments. The cartilages are hypermobile.

Fig. 12. Villous synovial thickening partially obliterating suprapatellar bursa.

tissue structures of the knee joint. This is demonstrated by the following case.

Case xii. (Fig. 15) Patient was wounded in action August, 1944. Shell fragment in right knee. Examination showed swelling of knee joint, pain and limitation of motion. Pneumoarthrogram, September 13, 1944, showed 1 by 1 cm. shell fragment partially impacted within the lateral aspect of the anterior supracondylar surface of the femur. The anterior surface of the fragment is in relation to the posterior reflection of the capsule of the knee. The bones of the knee are mildly decalcified. The upper portion of the suprapatellar bursa is obliterated.

Fig. 13. Small calcific deposit, posterior margin of the infrapatellar fat pad.

SUMMARY AND CONCLUSIONS

Pneumoarthrography is a simple and practical additional method of diagnosis in the study of internal derangements of the knee joint, and is of special value in clinically inconclusive cases.

The semilunar cartilages, cruciate ligaments, infrapatellar fat pad, synovia and the numerous bursae have certain normal roentgenologic characteristics. Deviation from these serve to indicate the type and degree of abnormality.

Fig. 14. Baker's cyst, left knee.

The following pneumoroentgenologic pathologic types have been demonstrated: Simple and bucket-handle type tears of the medial meniscus; dislocation and displacement of the meniscus; appearances in unilateral meniscectomy; cruciate tears of the ligaments; hypertrophy of the infrapatellar fat pad; synovial osteochondromatosis; osteochondritis dissecans; shell fragment in

Fig. 15. Shell fragment right knee. Soft tissue structure of knee joint outlined by air contrast.

relation to capsule of knee; chronic synovitis and Baker's cyst.

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ROENTGENOLOGY OF PARASITIC CALCIFICATION

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THE global nature of the fighting in World War II took the Allied troops to many areas where parasitic infestations were endemic and, despite careful hygienic measures, many of the troops became infested. The vast majority of parasitic infestations give rise to clincial symptoms which soon cause the patient to seek medical advice; a minority, however, only give rise to such slight or minor symptoms that their presence is unsuspected and they are only later detected as an incidental finding during roentgenologic examination. The majority of such parasites are

Fig. 1. Cysticercus of *Taenia solium* magnified 100×. The darkly stained areas represent calcification in the cyst wall.

not vital, but the dead parasite may cause serious symptoms by acting as an irritative foreign body. The majority of such parasites begin to calcify soon after death and consequently can be distinguished on the roentgenogram. The increased frequency of parasitic calcification in troops returning from overseas service is likely to further increase the difficulties of roentgenological diagnosis of ectopic calcification. It is therefore opportune at this moment to review the roentgenological appearances shown by these different types of parasites.

PATHOLOGY

Calcification in parasites occurs in two main sites: (*a*) calcification within the parasite; (*b*) reactive calcification in the tissues of the host.

Calcification within the substance of the parasite follows the same laws governing the deposition of calcium in any other dead tissue. The resulting calcification is amorphous and generally accurately follows the form of the original worm. Consequently, the nature of the original worm is clearly recognizable. Calcification in the parasite may involve the adult worm or the intermediate cystic stage.

Calcification of the cystic stage begins only with the death of the parasite. The calcification may be deposited in the embryo itself or in the investing membranes (the cyst wall) (Fig. 1). The cysts which most frequently calcify are the cysticerci (the cystic stage of *Taenia solium*) (Fig. 2). Considerable discussion has prevailed as to the exact site where calcification commences. Brailsford (1938)

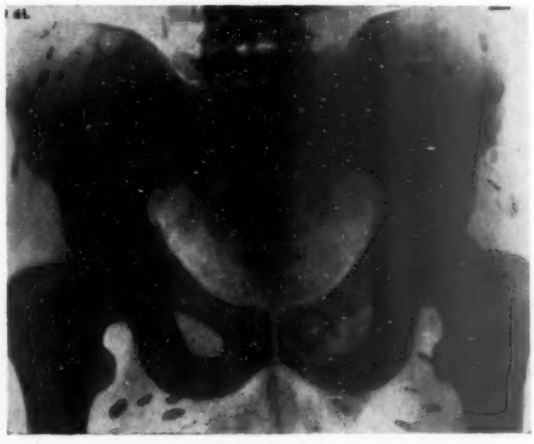

Fig. 2. Multiple calcified cysts present in the gluteal muscles. The cysts have the characteristic oval shape of cysts of *Taenia solium* encysted in the muscle planes.

has maintained that in the cysticercus calcification commences in the fluid within the cyst, others have maintained that calcification commences in the cyst wall, and others that calcification occurs in the scolex (i.e. dead embryo worm head), later spreading to the cyst wall. In intracerebral cysticerci calcification often occurs only in the scolex (Fig. 3 and 4), and as a result the correct etiology of the calcification may not be recognized in the roentgenogram.

Reactive calcification in the soft tissues

Fig. 3. Lateral roentgenogram of the skull showing dense calcified foci representing calcification in the scolices of *Taenia solium* (cysticercosis).

of the host is most frequently seen in organs which have a strong tendency to react to any form of trauma by calcification. The bladder is the best example of such an organ, and infestation of the bladder by *Schistosoma haematobium* results in extensive calcification in the submucosa of the bladder (Fig. 5). Reactive calcification is nearly always associated with calcification within the parasite, although the reverse frequently occurs.

There is considerable evidence to substantiate the idea that calcification in a cyst wall is far more likely to occur if infection of the cyst has occurred. True bone formation in the wall of the cyst has not been described and calcification is generally of the amorphous type.

Fig. 4. Calcified cysticerci in the brain. The dense pinhead calcification represents calcification in the scolices of the worm. The mottled ill defined calcification represents calcification in the cyst wall.

Roentgenological Classification

A suggested roentgenological classification of parasitic calcification is as follows:

(a) Calcification in the adult worm
  (i) *Dracunculus medinensis* (Guinea worm)
  (ii) *Loa loa* } only on very rare
  (iii) *Onchocerca* } occasions
(b) Calcification in the cystic stage
  (i) Cysticercosis (*Taenia solium*)
  (ii) Trichinosis (*Taenia saginata*)
  (iii) Hydatid cyst (*Taenia echinococcus*)
(c) Calcification in flukes
  (i) *Paragonimus westermani*
(d) Calcification in larvae
  (i) *Bilharzia* (*Schistosoma haematobium*) (*Schistosoma mansoni*)
(e) Protozoan parasites
  (i) *Toxoplasma*
(f) Calcification in nymphs.

(a) *Calcification in the Adult Worm.* The Guinea worm, endemic in India, Africa, Persia and Brazil, most commonly infests native troops but on rare occasions white troops may be involved. The life cycle of the worm is not clearly understood but it is thought that the larvae of the worm are

Fig. 5. Extensive calcification in the bladder in a chronic case of bilharziasis. The calcification is laid down in the submucosa of the bladder.

ingested and migrate through the stomach wall, reaching maturity in the retroperitoneal tissues. Thence the adult worms migrate to the subcutaneous tissues of the lower limbs. The female worm then discharges its larvae through a puncture on the skin. After death of the worm, calcification occurs in its body and it can be clearly demonstrated in the subcutaneous tissues of the lower limbs (Fig. 6) or scrotum (Fig. 7).

The worm may be coiled or uncoiled. In the uncoiled stage it appears as a thin calcified continuous streak in the subcutaneous tissue. Fractures may appear in the calcified streak if the affected area has been submitted to trauma (Fig. 8).

The uncoiled Guinea worm has to be differentiated from calcification in an artery. In the latter the calcification tends to form in parallel streaks or a broad band which is considerably wider than that of the worm, more irregular, and follows the anatomical course of the vessel. Furthermore, arterial calcification lacks the unbroken homogeneous calcification generally seen in the dead Guinea worm.

When the worm calcifies in a coiled mass the differential diagnosis is even more difficult. The difficulties are further increased by the fact that coiling of the worm tends to occur when it is deposited in the superficial tissues of the hands or feet (Fig. 6). Here it is very susceptible to trauma; hence the calcification is seldom continuous and the calcified mass is more often broken up into small fragments. Nevertheless a suggestion of the original coiled appearance can often be made out and the roentgen diagnosis is usually possible. It has to be differentiated from ectopic calcification, occurring in:

(1) *Hemangiomas.* Calcification in a hemangioma is more discrete and never as dense as that seen in a calcified Guinea worm and the round, homogeneous, phleboliths seen in a hemangioma are diagnostic.

(2) *Calcified Bursae.* Calcification in a bursa can be differentiated from a calcified Guinea worm by the anatomical site of the

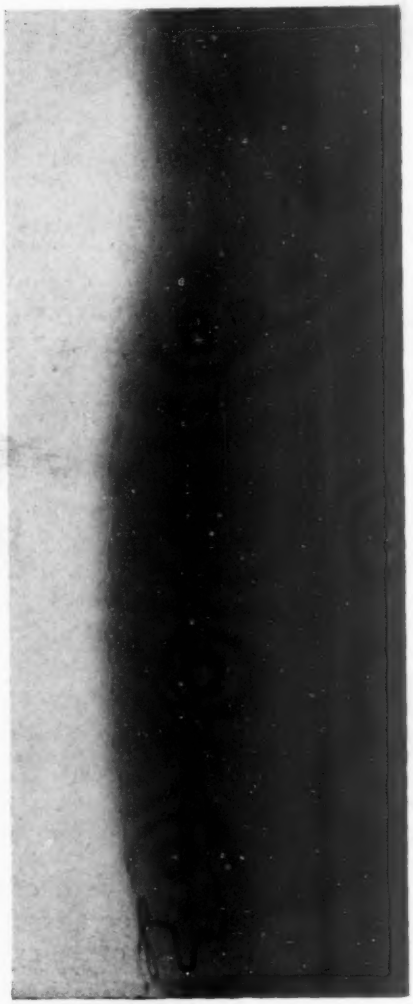

Fig. 6. Uncoiled calcified Guinea worm in the subcutaneous tissues of the lower limb.

Fig. 7. Calcified Guinea worms (coiled, partly curled) lying in the soft tissues around the perineum.

calcification and the irregular mottled appearance corresponding to a part or the whole of the bursa.

(3) *Tattoo Markings.* Tattoo markings on the skin may contain sufficient radiopaque substances to give some difficulty in diagnosis but usually inspection of the area immediately gives a clue to the diagnosis and a tangential view of the lesion reveals the true site of the opacities.

On rare occasions these Guinea worms may occupy the subcutaneous tissues of the overlying chest wall. Such ectopic calcification in chest roentgenograms may lead to the mistaken diagnosis of intrapulmonary calcified tuberculous lesions. Close inspection of the lesion will, however, reveal that the calcified mass has the characteristic coiled linear appearance of a worm (Fig. 9, *A* and *B;* 10, *A* and *B*), while a tangential view of the chest wall will reveal the calcification to lie in the thoracic wall.

The dead calcified worm seldom gives rise to symptoms but when it occurs near the synovial membranes it may cause irritative phenomena. Figure 11 shows a calcified worm lying in the extrasynovial tissue of the knee joint. Irritation of the synovial

Fig. 8. Fragmentation in the calcification in the Guinea worm.

membrane gave rise to recurring effusion into the knee joint. Surgical removal of the calcified worm is indicated only under such conditions.

Onchocerca volvulus (Fig. 12) and *Loa loa* are other members of the genus *Filaria* which affect man. They give rise to transient swellings in the subcutaneous tissues generally represents an auto-infestation.

The ova of *Taenia solium* when ingested migrate into the systemic arterial system whence they are carried to all parts of the body, notably the muscles and brain.

Unless the clinical diagnosis is made during the invasive stage the intramuscular cysts generally remain symptomless until

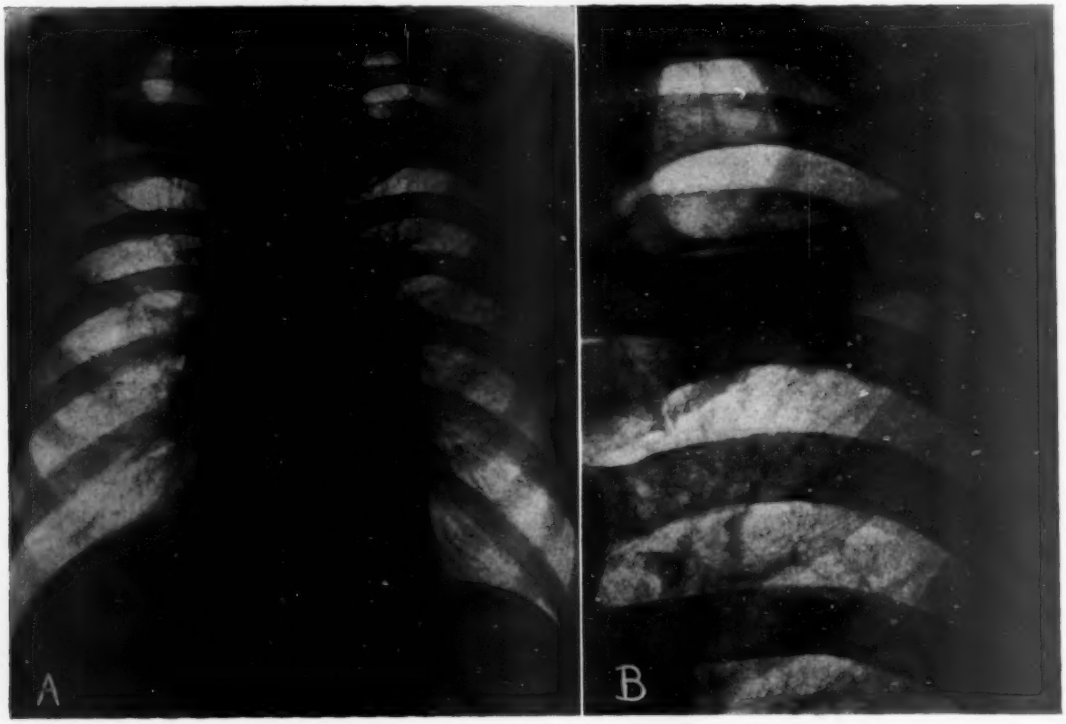

Fig. 9. *A*, posteroanterior roentgenogram of chest showing calcification in the left infraclavicular region and in the right mid zone simulating tuberculous lesions in the lung field. Contact films (*B*) demonstrate the whorled nature of the calcification. *B*, contact print of *A* showing the calcification lying in the left infraclavicular region. The appearance simulates a calcified mass in the chest but the coiled whorled appearance is characteristic.

often of considerable size but they calcify only on extremely rare occasions. I have not noted any examples of these in returning troops although one case referred for examination with the diagnosis of onchocerciasis was proved to have a metallic foreign body as the cause for the subcutaneous swelling!

(b) *Calcification in the Cystic Stage.*

Cysticercosis. Man is the natural definitive host for *Taenia solium* and the occurrence of the intermediate stage in man their counterpart in the brain die and on their death give rise to epilepsy. In other cases they are only discovered as an incidental finding.

The roentgen appearances of the intramuscular cysts are well known and have been described by numerous authors (Fig. 13). The earliest stage of calcification is classically described having the appearance of a small rain drop. The calcified cysts are not all of the same size and this is considered due to the fact that the parasites

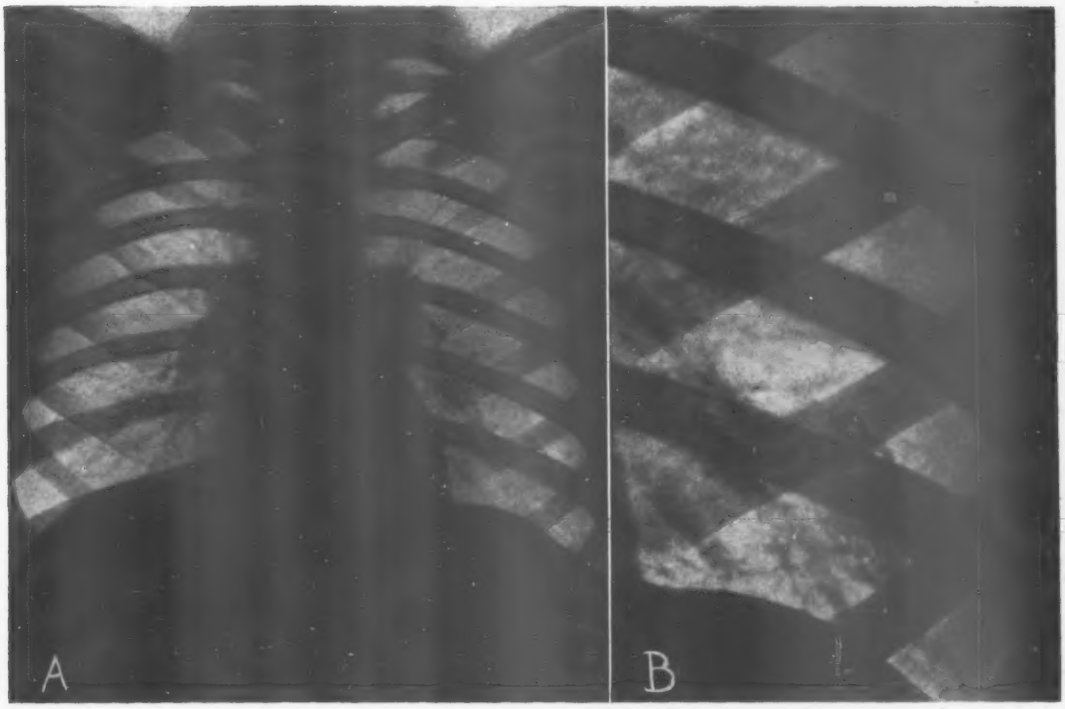

Fig. 10. *A*, posteroanterior roentgenogram of the chest showing coiled linear appearance apparently in the left lower lobe but actually lying in the superficial tissues. *B*, contact print of *A* showing the detailed appearance of the calcified mass.

Fig. 11. Calcified Guinea worm lying in the extrasynovial tissues and giving rise to recurring effusions into the knee joint.

die at different ages and it is only then that calcification commences in the parasite. Careful analysis of the calcified shadow will reveal that the calcification is patchy and a denser area corresponding to the calcified head of the worm (scolex) can be distinguished through the calcified cyst wall.

Fig. 12. Section through *Onchocera volvulus* showing absence of calcification (×110).

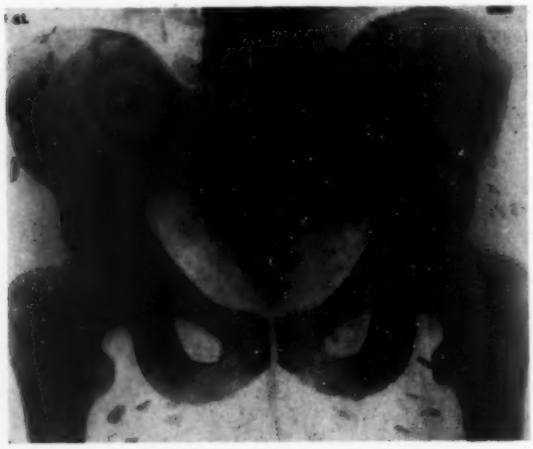

Fig. 13. Typical appearance of cysticerci in the muscles.

Intracranial cysts do not calcify nearly as frequently as those in muscles and the roentgen appearance differs considerably. With intramuscular cysts the oval nature of the calcification closely follows the shape of the original cyst which is almost certainly molded into an oval shape by muscular action. Intracranial cysticerci, on the other hand, not being subject to muscular pressure, tend to be round in shape. Calcification nearly always appears first in the scolex which appears as a dense area of calcification (Fig. 14). Calcification in the wall of the cyst appears as faint arcs or patches depending on whether the calcification is tangential to the incident ray (Fig. 15). Undoubtedly many cases of cysticercosis are reported as having negative skull roentgenograms owing to the fact that the different appearance of the intracranial calcification is not realized.

Trichinosis. Consequent on the ingestion of infected beef, the encysted stage (*Trichinella spiralis*) (Fig. 16) of the beef tapeworm (*Taenia saginata*) may occur in the human. Trichinosis gives rise to diverse symptoms varying from "grippe-like syndrome" to various allergic manifestations. Calcification of the cyst again does not occur until after the death of the parasite and although microscopically it is easy to demonstrate calcification in the cysts (Fig. 16) it is problematical if the degree and extent of the calcification is sufficient to be demonstrated roentgenologically.

Hydatid Cyst. The normal intermediate host for *Taenia ecchinococcus* is the pig and

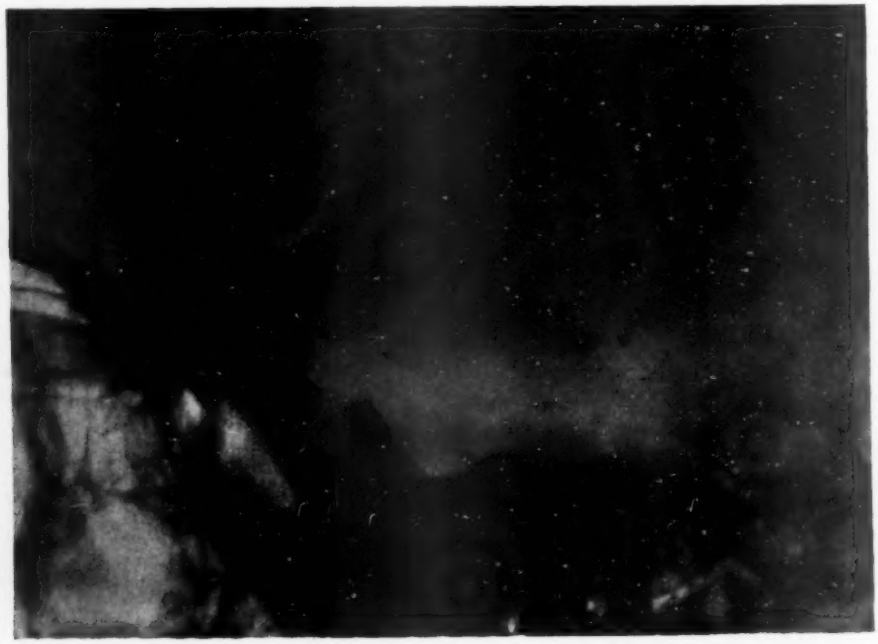

Fig. 14. Note the dense central areas of calcification representing calcification in the scolex of the worm.

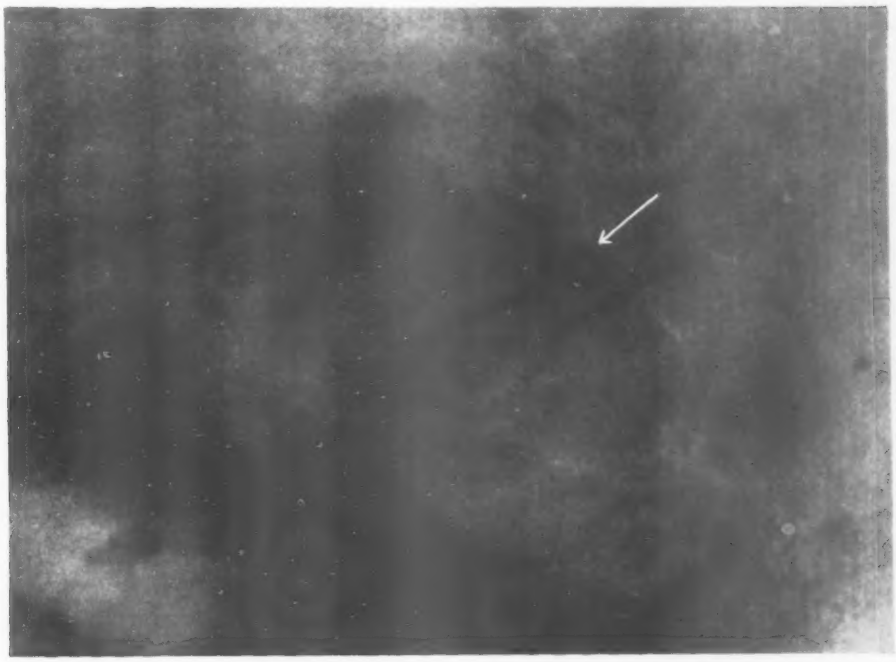

Fig. 15. Contact print of Figure 3 showing the minute detail of calcification within the cyst wall. The arrow points to the densely calcified central scolex and the peripheral linear calcification. Note also the round shape of the shadow.

the definitive host the dog. The infestation may under certain conditions be transferred to the human who acts as the intermediate host. Generally, hydatid cysts give symptoms long before calcification appears in the cyst wall. Occasionally they may remain silent until they are discovered as an incidental finding at roentgenologic examination or at necropsy.

Calcification involves the wall, both the true cyst wall and the reactive tissues of the host. Intra-abdominal hydatid cysts tend to calcify more frequently than similar cysts in any other part of the body and anatomically tend to be located in the liver or mesentery. Hydatid cysts in bone occur

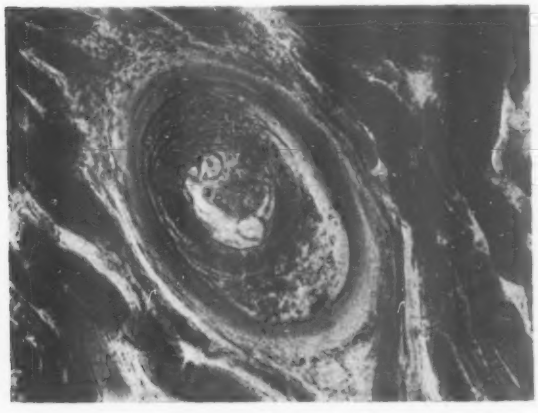

Fig. 16. Section through a cyst of *Trichinella spiralis* (×150) showing typical appearance.

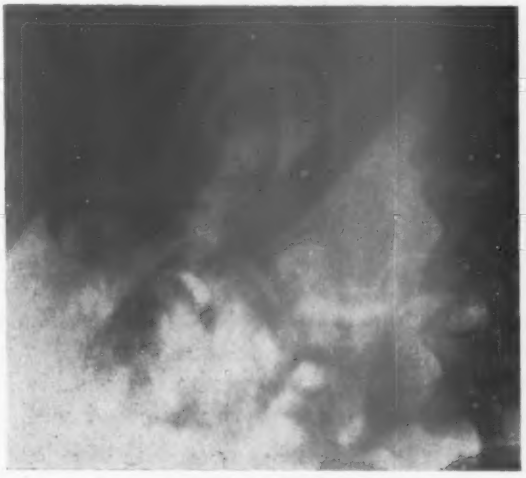

Fig. 17. Calcification in the gallbladder (contact print) mimicking a calcified hydatid cyst.

in the medullary cavity where they seldom show features characteristic of a cyst as they are deformed by the rigid bony cortical walls. Calcification in the intramedullary cyst is a frequent occurrence and the roentgenologic appearance is slight expansion of the bone with wavy linear calcification in its center.

Fig. 18. Calcification in a solitary tuberculous mesenteric gland which may simulate a calcified hydatid lesion. Here the mottled appearance indicates the correct diagnosis.

Hydatid cysts in the liver are another frequent site of calcification. Calcification in hydatid cysts appears as mottled irregular plaques or linear streaks. Two or three cysts may calcify. It has to be differentiated from calcification in the wall of a chronic amebic abscess. This can readily be done as in the latter the calcified wall is thicker and more irregular. Calcification in a gallbladder may also give rise to difficulties in diagnosis. Here the diagnosis generally rests on the pear shape and correct anatomic location of the shadow (Fig. 17). Hypernephroma of the kidney may also calcify and here the calcification generally tends to be of eggshell type around the periphery of the tumor and consequently may closely mimic a hydatid cyst. Calcification in tuberculous glands (Fig. 18) may also give difficulties in differential diagnosis.

(c) *Calcification in Flukes.* Infestation with liver flukes is endemic in Western China but examples of such infestation in white troops are extremely uncommon. Nevertheless on rare occasions such infestations may occur and even more rarely such flukes may calcify.

Lung flukes do not tend to calcify and hence seldom give rise to difficulties in the differential diagnosis of heterotopic calcification.

(d) *Calcification in Larvae. Schistosoma haematobium* is endemic in many parts of the world and is especially common around the Eastern Mediterranean and in India. The clinical symptoms are usually sufficiently severe to attract medical attention, and confirmation of the clinical diagnosis can be made by finding the parasite in the urine. The infestation is especially common in Indians and inhabitants of the Eastern Mediterranean and in such subjects medical advice may not be sought with the initial infestation (Fig. 19, 20 and 21). In such cases attention may be first drawn to the condition by the discovery of a calcified bladder. Under certain conditions this parasite has infested white troops.

Calcification of the bladder in infestation with *Bilharzia* occurs only when the disease is chronic and the calcification is laid down in the submucosal plane in thin plate-like plaques. The resulting appearance is that of a thin sphere of calcification having a superficial resemblance to a fetal head occupying the vesical area.

The lower ends of the ureters are frequently involved and calcification in the walls of the ureters appears as linear markings arising from the posterolateral angles of the bladder.

Calcification in the bladder wall has to be

differentiated from calcification in the wall of a tuberculous bladder. Features which enable the differential diagnosis to be made are: first, distensibility of the bladder. This diagnostic sign is dependent on the different planes in which the calcification is laid down in the vesical wall. In the parasitic type, as already described, calcification involves the submucosal wall and consequently the muscular wall of the bladder is unaffected. In tuberculous disease the process involves the whole bladder wall and the destruction of the muscular wall with consequent fibrosis and calcification results

Fig. 19. A case of bilharziasis showing advanced calcification in the bladder wall and in the lower end of the left ureter. Stone formation is present in the lower end of the left ureter. Figure 20 shows the distensibility of the bladder.

in a loss of its distensibility. The calcified tuberculous bladder is always considerably smaller in capacity than normal. Second, calcification along the ureter tends to be much more common in bilharzial infestations than in tuberculous infections and extensive bilateral calcification of the ureter is almost pathognomonic of parasitic infection.

It is important to differentiate the linear calcification in the lower end of the ureter from calcification in the wall of the

Fig. 20. Calcified bladder showing the linear calcification within the bladder wall. The bladder has been distended. Note the calcification in the lower end of the ureter.

Fig. 21. Calcified bladder from another case of bilharziasis showing the typical appearance.

internal iliac artery. Careful examination of the roentgenogram will show that the calcification follows the anatomical course of that vessel and that some calcification in the branches can be seen.

Infestation with *Schistosoma mansoni* gives findings somewhat similar to those of the *Schistosoma haematobium* and involves the rectum. Calcification in the rectal walls does not occur and the rectal symptoms generally make the diagnosis clear.

(e) *Protozoan Parasites.* The occurrence of *Toxoplasma* as a cause of multiple intracerebral and intrapulmonary calcification has only been recognized recently. Comprehensive accounts of calcification due to this parasite have already been described. The condition has to differentiated from calcified intracerebral cysticerci and this is easily done by the presence of calcified intramuscular cysts in the latter.

(f) *Calcification in Nymphs.* The nymph stage of the *Armillifer armillatus* may form extensive calcification in the celomic cavities of the adult. The adult stage lives in the trachea of certain snakes. Man becomes infested by handling infected secretions from the snake. The calcified nymph has a characteristic comma-like appearance which enables it to be differentiated from the cysticercus cellulosa.

SUMMARY

1. Calcification may occur in a large number of parasites.

2. Its appearance generally indicates death of the parasite or the intermediate cyst stage.

3. Parasitic calcification tends to be amorphous and it may cause difficulties in differential diagnosis of ectopic calcification.

4. Parasitic calcification tends to accurately follow the outlines of the dead worm and a knowledge of the shape of the worm will enable the correct diagnosis to be made.

The author wishes to acknowledge his indebtedness to Lieutenant Colonel W. H. Hargreaves, O.B.E., R.A.M.C., Major Stephen Maddocks, R.A.M.C., Major J. A. Brocklebank, R.A.M.C., and Major Gautby, R.A.M.C., for permission to publish several of the illustrations.

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A COMPARATIVE ANATOMICO-ROENTGENOLOGICAL STUDY OF THE CERVICAL SPINE OF TWENTY CADAVERS*

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NEW HAVEN, CONNECTICUT

INTRODUCTION

CERVICAL posterior herniations of the nucleus pulposus may show thinning of the involved intervertebral discs on lateral roentgenograms; however, the discs between the fifth and sixth and sixth and seventh cervical vertebrae are often thinned without herniations and concurrent symptoms (Bradford and Spurling[3]). A disc involved in a posterior herniation is not invariably thinned, however (Spurling and Scoville[12]). Thinned intervertebral discs may cause narrowing of the intervertebral foramina and compression of cervical spinal nerves ("discogenetic disease" of Oppenheimer[11]). Arithritic changes were observed in the apophyseal joints of 20 per cent of the latter patients.

In 25 cadavers, Horwitz[7] found that roentgenograms of the cervical spine frequently revealed arthritic changes in the joint spaces, which were usually associated with degenerative changes in the discs and vertebrae.

Thinning of the lower cervical discs in older individuals, with vertebral lipping and bony sclerosis, has been called the "geredisc" (Hadley[6]). The cervical nerves occupy one-fourth to one-fifth of the diameter of their intervertebral foramina, and marked foraminal constriction is not always necessary to produce nerve compression (Hadley[6]).

Intraspongious prolapses of the nucleus pulposus (Schmorl's nodules) can be observed roentgenologically only when calcified or surrounded by a zone of bony sclerosis (Compere and Keyes;[5] Junghanns;[9] Horwitz and Smith[8]). Artificial defects in the vertebral bodies of 2 to 6 mm. in diameter were packed with disc material, but were not visible on roentgenograms (Horwitz and Smith[8]). Schmorl's nodules 15 mm. in diameter have not been visualized (Chasin[4]), whereas defects measuring 4 by 6 by 9 mm. have been seen (Wagoner[13]).

There are many clinical reports of compression of the spinal nerves or cord by hypertrophic arthritis of the posterior edges of the vertebral bodies (Bailey and Casamajor;[1] Barré;[2] S. A. Morton;[10] Oppenheimer[11]).

MATERIALS AND METHODS

Lateral and right and left posterior oblique roentgenograms were made of the cervical region of 20 spinal columns, which were removed from cadavers by sawing through the angles of the ribs and removing the soft tissues.

On 6 specimens lipiodol, or barium sulfate, or a fluid contrast medium (ditopax) was used for cervical myelograms, but it was difficult to get adequate filling of the subarachnoid space by cervical spinal puncture or insertion of the materials through the vertebral foramen of the atlas. After the roentgenographic studies, the spinal columns were completely dissected in the cervical region.

The ages of 18 of the individuals at death were known, and averaged 64.9 years. Two specimens were from female cadavers.

* This work was aided by a grant from the James Hudson Brown Memorial Fund of the Yale University School of Medicine, and comprised a portion of a thesis written for the degree of Doctor of Medicine. Drs. Hugh M. Wilson and Dorothea R. Peck have furnished much inspiration and technical assistance.

CHANGES IN THE INTERVERTEBRAL DISCS

Brown degeneration of the discs (Horwitz[7]) was not visible on the roentgenograms, although it was found in the cervical discs of 9 specimens (Fig. 1, 4 and 8). Fissuring of the cervical discs was also not detectable on roentgenograms, although fissures longer than 3 mm. were observed in 3 specimens at dissection (Fig. 1). Ossification of 1 thinned cervical disc was noted, and the findings confirmed at dissection (Fig. 1).

Uniform thinning of discs between the fifth and sixth or sixth and seventh cervical vertebrae was observed on the lateral roentgenograms of 8 specimens (Fig. 1 and 2). Other discs were involved in 3 of the 8 specimens (Table 1). The close association of thinning with the above pathological conditions was much less marked in other spinal regions (unpublished data).

None of the 6 cervical Schmorl's nodules in 5 specimens appeared on the roentgenograms (Fig. 1, 4 and 8). All were less than

Fig. 1

Fig. 2

Fig. 1. Lateral roentgenogram of the cervical region, showing thinning of discs between the fourth and fifth and sixth and seventh cervical vertebrae, anterior lipping and eburnation of vertebral bodies of the fifth and sixth cervical vertebrae, the fusion of vertebral bodies of the sixth and seventh cervical vertebrae and the ossification of the remaining part of disc between the sixth and seventh cervical vertebrae. The Schmorl's nodule in the body of the fifth cervical vertebra is not visible. Brown degeneration and fissuring of disc between seventh cervical and first thoracic vertebrae are not evident. Male, aged seventy-nine. ×¾

Fig. 2. Lateral cervical myelogram showing marked posterior lipping which indented the cord (cf. Fig. 3 and 6). Anterior lipping and disc thinning are also evident. Male, aged sixty-seven. ×¾

4 by 4 by 4 mm. in size. Disc thinning was present in 3 of the 6 instances. Eburnation of the adjacent vertebral bodies was noted in 2 of the 3 instances of thinning, and posterior lipping of the vertebral centra once. Three discs with Schmorl's nodules were otherwise normal roentgenographically and at dissection.

Fig. 3. Photograph of the ventral surface of the spinal cord from the specimen shown in Figures 2 and 6, showing indentation by posterior lipping of the vertebral bodies. The ventral portion of the dura has been reflected to the left. ×1

Posterolateral herniation of the nucleus pulposus was present in one instance, but could not be detected on the roentgenogram itself; however, thinning of the disc was visible, as was posterolateral lipping of the vertebral bodies which aided in compressing the left seventh cervical nerve against the superior articular process of the seventh cervical vertebra (Fig. 8).

Posterior protrusion of the annulus fibrosus of cervical discs, without herniation of the nucleus pulposus, was present twice, and could not be detected roentgenographically except for thinning of the

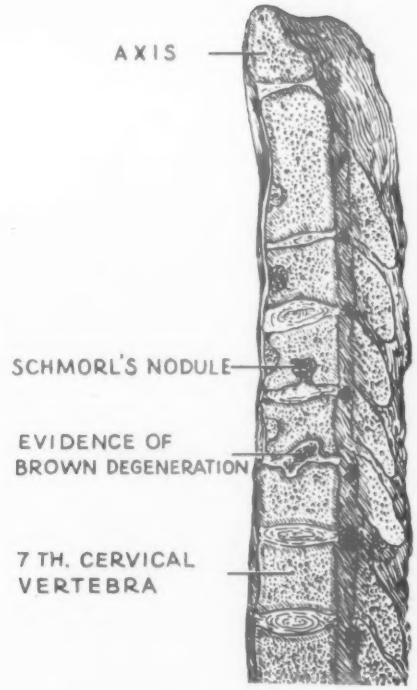


Fig. 4. Longitudinal section showing the right half of the cervical region. Disc thinning and loss of the cervical curvature are evident. Male, aged fifty-one. ×⅔.

posterior part of the disc. The posterior protrusions did not cause indentation of the spinal cord or nerves in either instance. The protruding annular fibers extended

Table I

Changes Associated with Uniform Thinning of the Disc between the Fifth and Sixth or the Sixth and Seventh Cervical Vertebrae in Eight Specimens

	Number of Specimens Involved	Visible Roentgenographically	Visible at Dissection
Thinning	8	Yes	Yes
Posterior nuclear herniation	1	No	Yes
Brown degeneration	4	No	Yes
Fissuring	3	No	Yes
Schmorl's nodules	3	No	Yes
Ossified disc	1	Yes	Yes
Vertebral eburnation	5	Yes	Yes
Posterior lipping	5	Yes	Yes
Articular arthritis	2	Yes	Yes

less into the spinal canal than did the nuclear herniations; however, the whole posterior edge of the disc was involved instead of the localized area in the latter.

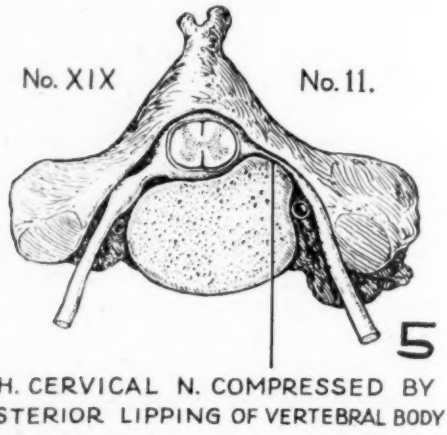
CHANGES IN THE VERTEBRAE

The heights of the centra of the fifth and sixth cervical vertebrae were decreased in 9 specimens, and the adjacent discs were thinned in 2 of these instances. These conditions were noted on the roentgenograms and confirmed at dissection (Fig. 1 and 2).

Five specimens had eburnation of the vertebral bodies roentgenographically and at dissection (Fig. 1). On the films it appeared as areas of increased density adjoining thinned disc spaces. Although it was invariably associated with thinning of the discs, the latter was not always accompanied by eburnation. The association of eburnation with other degenerative changes was not constant.

Anterior lipping was noted in 17 specimens (85 per cent; Fig. 2 and 6). It was especially prominent over the anterolateral aspects of the cervical vertebral bodies, and was best visualized on oblique roentgenograms (Fig. 7 and 8).

Lipping of the posterior edges of the cervical vertebral bodies was noted in 17 specimens also (85 per cent). The anatomico-roentgenological correlation was exact with regard to incidence and extent. The lipping was extensive enough in 3 instances to indent the anterior surface of the spinal cord 1 or 2 mm. (Fig. 2, 3 and 6). The lateral myelograms emphasized the condition observed on conventional films. Posterolateral lipping produced nerve compression in 2 instances. In both, the anteroposterior diameters of the intervertebral foramina on the oblique roentgenograms were markedly decreased by posterior lipping of the vertebral bodies (Fig. 8). At dissection, these 2 specimens, and 4 others with nerve compression (from another series of 20 cadavers not studied roentgenologically), showed that compression resulted from the nerve being caught between a posterior exostosis on the vertebral body and the superior articular process or lamina of the same vertebra, the inferior half of the intervertebral foramen having been especially constricted (Fig. 5). In one instance arthritis of the articular processes contributed to the nerve compression (Fig. 6). The anteroposterior diameter of the foramen was less than 3 mm. in both cases of nerve compression. Posterior lipping contributed to the narrowing of foram-



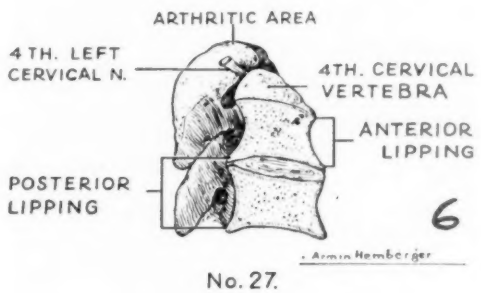


Fig. 5. Semidiagrammatic transverse section to show the mechanism of nerve compression by posterolateral lipping. Frequently the lipping was more lateral than indicated here, so that the nerve was compressed against the superior articular process instead of the lamina. $\times \frac{2}{3}$

Fig. 6. Longitudinal section showing the left half of two cervical vertebrae. The fourth left cervical nerve is compressed by a combination of posterolateral lipping and articular arthritis (cf. Fig. 2 and 3). $\times \frac{2}{3}$.

ina in 10 specimens without nerve compression, and the lipping, but not the presence or absence of compression, could be detected roentgenologically (Fig. 7).

Ten specimens (50 per cent) had one or more small interpedicular foraminal diameter (less than 7.5 mm.). Eight of these had uniform or posterior thinning of the corresponding intervertebral disc, and 7 an accompanying posterior lipping, both factors having been observed roentgenologically (Fig. 8). Ten specimens also revealed one or more foramina narrowed in its anteroposterior diameter (less than 3.5 mm.). Posterior lipping contributed to the narrowing in each case (Fig. 7); however, 1 posterior nuclear herniation and 2 instances of posterior annular protrusion caused more narrowing of the foramina than the lipping, and could not be seen on the roentgenograms. Articular arthritis contributed once to the anteroposterior foraminal narrowing (Fig. 6). In all but one specimen, either foramina between the

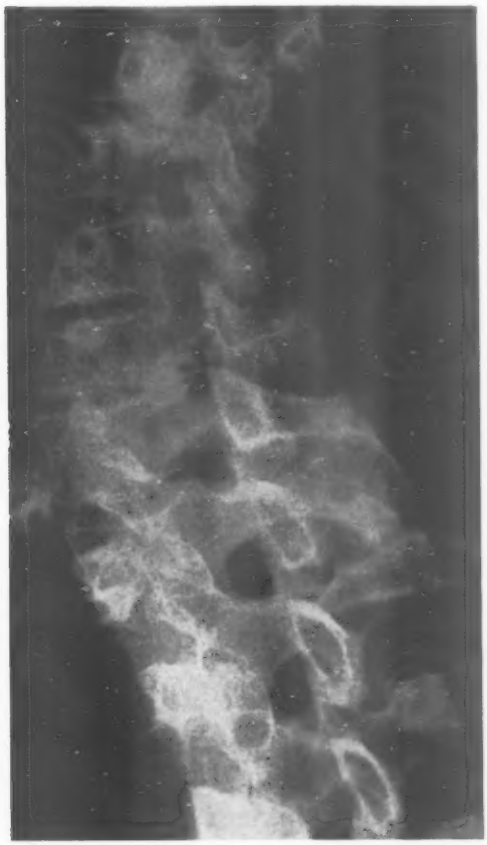


Fig. 7

Fig. 8

Fig. 7. Right posterior oblique roentgenogram showing the left intervertebral foramina. The foramen between the sixth and seventh cervical vertebrae is narrowed by posterolateral lipping of the vertebral bodies, but the nerve was displaced into the inferior half of the foramen and not compressed. Anterolateral lipping is also evident. Male, aged seventy-four. ×¾.

Fig. 8. Right posterior oblique roentgenogram of the specimen shown in Figure 4. The left seventh cervical nerve was compressed by posterolateral lipping and a posterior nuclear herniation (not seen here). The widths of the foramina are slightly distorted since the specimen was not in an exact oblique position. The Schmorl's nodule in the body of the fourth cervical vertebra is not visible. Male, aged fifty-one. ×¾.

fifth and sixth or the sixth and seventh cervical vertebrae were involved, but in 8, one or more other foramina were affected also. The correlation between narrowing of the anteroposterior and interpedicular foraminal diameters was not constant.

Articular arthritis was noted in 2 specimens (10 per cent). The films indicated ankylosis of the left zygapophysial articulation between the third and fourth cervical vertebrae in one specimen (Fig. 6), and the right sixth and seventh cervical vertebrae in another. Both discs were thinned, and in the latter instance, ossified (Fig. 1).

DISCUSSION

It is probable that many Schmorl's nodules are missed in the roentgenological study of the spine. Since there was not a constant association of disc thinning, vertebral eburnation, and lipping with the nodules in these studies, it is unlikely that the condition can be identified unless the nodules are calcified or surrounded by sclerosed bone, as has been reported. Since half the discs with Schmorl's nodules appeared otherwise normal, the significance of the condition in the production of degeneration of the discs is questionable; however, it should be borne in mind that 20 specimens do not represent a quantity large enought to claim statistical accuracy.

Thinning of the discs, vertebral eburnation, and lipping were also not characteristic of posterior herniations of the nucleus pulposus only, having been present in discs and vertebrae not so involved; therefore, it is probable that too much emphasis has been placed upon these roentgenographic signs in diagnosing posterior herniations. Theoretically posterior nuclear herniations might be distinguished from annular protrusions myelographically by the lesser extension of the latter into the spinal canal, but with involvement of the whole width of the disc instead of the more localized area in posterior herniations.

It was difficult to predict from conventional roentgenograms when posterior lipping was extensive enough to produce compression of the spinal cord, but myelograms should be helpful in determining it. Case histories were not available, and it is not known whether symptoms were produced in the 3 instances of cord compression. Lipping probably progresses so slowly that the cord and its blood supply can adjust to the gradually increasing pressure for some time.

It was also difficult to predict compression of the spinal nerves from the oblique roentgenograms of the intervertebral foramina; however, the following points based particularly on the anatomical studies of these, plus 20 other cadavers, may help in determining nerve compression due to posterior lipping of the vertebral bodies: (1) Avoid distortion of the foramina by placing the patient or specimen in an exact oblique position of 45 degrees. (2) Nerve compression is more likely when the inferior half of an intervertebral foramen is markedly decreased in size by an exostosis from the posterior edge of the inferior vertebral body involved in the lipping. (3) The less the area remaining in the inferior half of a foramen, the more likely is nerve compression.

Oppenheimer's theory of "discogenetic" narrowing of the intervertebral foramina was partially confirmed; however, posterior vertebral lipping was the factor really responsible for nerve compression in the two instances noted.

Narrowing of the sixth and seventh cervical vertebrae and discs, and foramina between the fifth and sixth and sixth and seventh cervical vertebrae may be due to the transition between the freely movable cervical and the more fixed thoracic vertebrae.

SUMMARY AND CONCLUSIONS

1. Roentgenograms were made of the cervical spines of twenty cadavers, after which the spinal columns were dissected.

2. Brown degeneration and fissuring of the intervertebral discs, posterior herniations of the nucleus pulposus, posterior pro-

trusions of the annulus fibrosus, and Schmorl's nodules could not be detected roentgenologically, whereas lipping and eburnation of the vertebral bodies, thinning and ossification of the discs, and articular arthritis were visible on the roentgenograms.

3. The comparative incidence of disc thinning and other conditions mentioned above was noted. Posterior vertebral lipping indented the spinal cord three times and compressed the spinal nerves twice. Narrowing of the inferior half of the intervertebral foramen was especially significant in the latter instances.

4. The inability to detect Schmorl's nodules roentgenologically may be insignificant, since their importance in disc degeneration s equivocal.

5. Disc thinning, vertebral eburnation, and lipping are not characteristic of posterior herniations of the nucleus pulposus only, and perhaps have been overemphasized in the roentgenological diagnosis of the latter.

6. The higher incidence of signs of wear and tear in the lower cervical vertebrae and discs is probably due to the transition between the freely movable cervical and the more fixed thoracic region.

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ROENTGEN DIAGNOSIS OF PLEURAL MESOTHELIOMA (ENDOTHELIOMA)*

CASE REPORT

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PLEURAL endotheliomas usually manifest themselves by pleural effusions that rapidly reaccumulate following thoracentesis.[6] According to Piatt,[4] the roentgenogram is of no help in early cases at which time there may be only a slight effusion at the base. Later a massive effusion develops, usually accompanied by a shift of the mediastinum; after the removal of the fluid a thickened pleura is often observed. An unusual case, reported by Heise and Trudeau[1], showed at first only spontaneous pneumothorax; later pleural effusion and thickened pleura became evident.

Tumor masses may be seen, but as a rule are observed with difficulty.[4] It has been suggested[7] that "air should be introduced into the pleural cavity after an aspiration. The film then reveals the characteristic multiple smooth tumor nodules of various sizes and thickness, mostly over the parietal pleura, with the lung markedly collapsed in most cases." However, Lindqvist and Bergstrand[3] reported a case of pleural endothelioma where the diagnosis was made from plain roentgenograms. Here there was roentgen evidence of an intrapleural shadow so dense and so localized that it could only represent a pleural tumor. It was a case of a fifteen year old student who was suddenly seized with symptoms of pleurisy but no pleurisy was found and the diagnosis of pleural tumor was confirmed at operation.

CASE REPORT

C. B. (Unit No. 58718), a white male, aged sixty-two, was first seen on May 18, 1946, at the Episcopal Hospital. He complained of an intermittent sticking pain of ten weeks' duration in the region of the scapula, more severe at night, and sometimes preventing sleep. He felt better when sleeping in a semi-erect position. The pain was made worse by exertion; it was not relieved by nitroglycerin. Later he developed a burning sensation in his left axilla and over the left mid-anterior chest region.

Physical examination revealed a clear chest. There was an irregular area of inconstant paresthesia over the fourth to fifth ribs on the left posteriorly. Examination of the heart showed a grade 2 mitral murmur with the point of maximal impulse 11 cm. to the left of the mid-sternal line. The liver edge was smooth and five fingers' breadth below the costal margin. There was clubbing of the fingers.

Laboratory Studies. Urinalysis, blood count, acid and alkaline phosphatase determinations, blood calcium and phosphorus, and serum protein were all within normal limits. Kolmer and Kahn tests, examination of spinal fluid, and examination for Bence-Jones protein were all negative.

Roentgen Studies. Roentgen examination of the chest on May 27, 1946, showed an area of homogeneous density along the left lateral chest wall. This had the appearance of pleural thickening localized to the upper half of the pleural space. Some fibrotic strands were present in the left lung opposite the hilum (Fig. 1). Several weeks later osteolytic lesions were found in the left upper ribs (Fig. 2). A skeletal survey and a complete gastrointestinal examination were both negative and helped to exclude an extrathoracic primary malignancy.

The patient was bronchoscoped several times. At first the examinations were negative. Later the bronchoscopist found a slight compression of the lumen of the distal portion of the left main bronchus. He felt that the best possibility was an extrapulmonary lesion, or if parenchymal in origin, very peripheral in location.

Later a pleural friction rub was noted on deep inspiration in a very localized area over the left second rib anteriorly.

Roentgen therapy to the left upper chest was

* From the Department of Radiology, Dr. D. A. Sampson, Director, Episcopal Hospital, Philadelphia, Pa.

started on September 25, 1946, because of intractable pain and because the patient's retrogressive course and other features of the case had led to a diagnosis of malignant chest tumor. In retrospect, further evidence as to the nature of the chest disease might have been obtained at this time by a diagnostic thoracentesis. A plugged needle might have furnished tumor cells.[2] Furthermore, the resistance encountered as the needle is pushed through the thickened tumorous pleura has been reported to have diagnostic value.[4] The dose was 3,000 roentgens (in air) to both the anterior and posterior portions of the left chest (factors: 200 kv., 0.5 mm. Cu and 1.0 mm. Al, 50 cm. skin target distance, 300–400 r daily) delivered over a period of about two months. There was no appreciable relief from pain or roentgen evidence of tumor regression.

The pain became progressively worse. A tugging and constricting feeling over the left side of the chest developed. Physical examination on December 9, 1946, showed: (1) left Horner's syndrome with excessive perspiration over the entire right side of the body; (2) marked atrophy of the left cervical muscles with a deepened left supraclavicular fossa; (3) no deviation of larynx or trachea or cardiac displacement; (4) vocal fremitus over the left chest posteriorly with decreased breath sounds; (5) immobility of the left chest on inspiration with fixation of the left leaf of the diaphragm at a level 8–12 cm. above that of the right; (6) occasional rales over both sides of the chest; (7) tenderness to percussion of the left anterior chest wall; (8) wheezing in the left hilar region; (9) marked lumbar scoliosis.

On January 8, 1947, the blood count showed a red blood cell count of 2,800,000 with a hemoglobin of 8.5 gm. (58 per cent); the white blood cell count was 4,700 with 72 per cent polymorphonuclears, 26 per cent lymphocytes, and 2 per cent eosinophils.

Further Roentgen Studies. On September 28, 1946, there was noted considerable elevation of the left dome of the diaphragm with the linear strands in the left mid-lung field and the pleural thickening now more prominent (Fig. 3 and 4). The left dome of the diaphragm was immobile. These findings were interpreted as indicating possible phrenic paralysis with or without collapse of the left lower lobe and tumorous fixation of the diaphragm. Examination of the thoracic spine showed no metastases.

A neurological consultant on January 31, 1947, confirmed the presence of findings such as would develop with a left sympathectomy, viz. Horner's syndrome plus failure of the left side of the trunk to perspire. There was on the

Fig. 1. Roentgen examination (May 27, 1946) showing density along the upper portion of the left lateral chest wall.

Fig. 2. Osteolytic lesions involving the anterior portions of the left upper ribs.

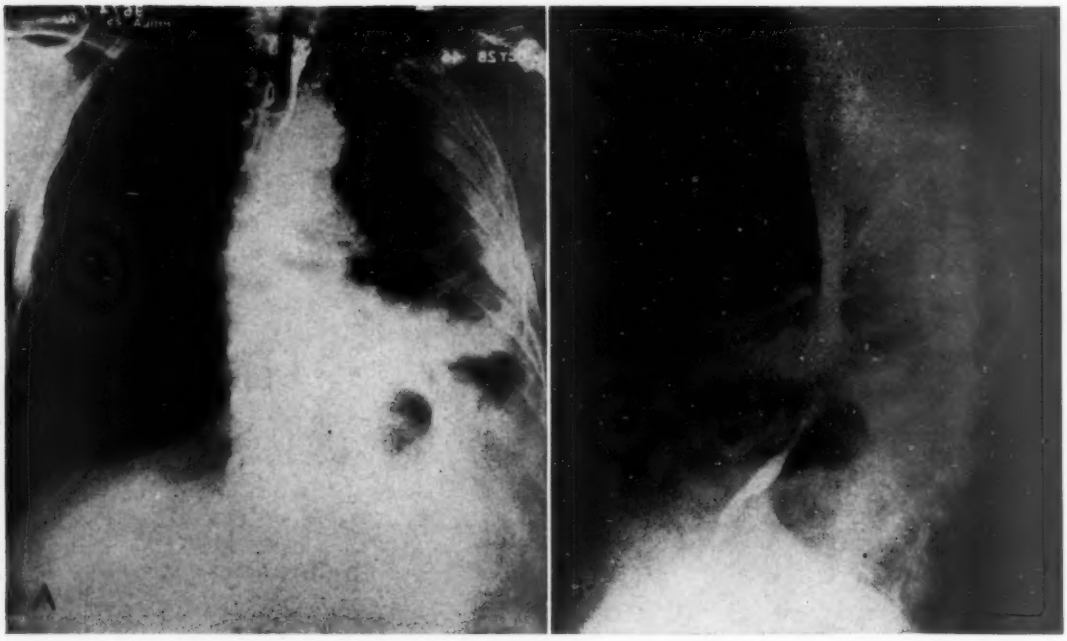

Fig. 3. (*A*) October 28, 1946. Note the increased chest wall density (pleural thickening) and paralysis of the left hemidiaphragm; also scoliosis with convexity to the right. (*B*) October 28, 1946. Left lateral view.

left side skin anesthesia of the area supplied by T5-T11 inclusive.

The patient's course was rapidly retrogressive. Venous distention of the left side of the neck developed, the left lobe of the liver became nodular and pitting edema appeared over the sacrum and lower extremities. He died on February 9, 1947.

Autopsy and Microscopic Findings: (Performed by Dr. A. R. Peale, Associate Professor of Pathology, Temple University School of Medicine.)

Fig. 4. (*A*) Progressive changes as noted in December, 1946. (*B*) Left lateral view.

External inspection of the body revealed pigmentation of the skin of the left chest resulting from irradiation. Internal inspection of the abdominal cavity revealed no free fluid or exudate in the peritoneal sac. The liver extended three fingers' breadth below the right costal margin. The spleen was not enlarged. The stomach was dilated and distended reaching to the umbilicus. The small and large intestines were moderately distended with gas.

Inspection of the thoracic cavity showed the heart to be slightly enlarged to the left. Its pericardial sac contained about 10 cc. of blood-tinged serous fluid. The left pleural cavity was completely obliterated. Its parietal and visceral layers were densely adherent and considerably thickened by tumor proliferation. In some areas the pleura was easily 3 cm. in thickness. The tumor formed a complete cast of the left chest cavity. It was firm and rubbery in consistency, assuming a cartilaginous density. The tumor involved the entire left pleura including the diaphragmatic surface (Fig. 5). It penetrated the interlobar septum, thickening this structure and infiltrated the left side of the aorta and its posterior surface down to the level of the third lumbar vertebra, thus involving practically all of the sympathetic nerve chain and the posterior roots on this side. The tumor stopped abruptly at the midline. The neoplasm was tightly adherent to the posterior and lateral walls of the chest cavity, invading many of the contiguous ribs. The anterior surface of the left fourth rib was similarly invaded. The corresponding lung was compressed and atelectatic. The right pleura contained a few metastatic tumor nodules on its posterior wall. The second, fourth and seventh ribs on this side each presented an area of metastasis.

The heart weighed 445 grams. There was moderate right-sided dilatation and mild left ventricular hypertrophy. The striking gross pathological change was the tumor-studding of the epicardial surface, which took the form of nodules and flat plaques. These were firm and involved practically the entire epicardial and myocardial junctions, failing to invade the contiguous muscle tissue. The myocardium on cut section showed moderate loss of normal color and consistency. The endocardium and valves were grossly healthy except for dilatation of the tricuspid ring and mild atherosclerotic thickening of the mitral and aortic cusps. The coronary ostia were widely patent and their corresponding vessels exhibited minimal atherosclerosis.

The intimal surface of the aorta was clean and smooth throughout for the most part. The penetration of the tumor process around the left side and posterior border has been described. There was no infiltration of the wall of the vessel.

The left lung with attached pleural tumor weighed 1,020 gm. There was no direct invasion of the lung by tumor although there were metastatic nodules in both lobes with peribronchial and perivascular distribution. The right lung weighed 950 gm. The parenchymal tissue was poorly aerated as a result of edema and congestion. Scattered throughout all lobes there were a few small tumor nodules varying from 1 to 3 mm. in diameter. The lymphatics on the visceral pleura of the lower lobe stood out as a lattice-work pattern with occasional nodularity indicating permeation by tumor. Careful exploration of the bronchial tree failed to disclose an intrabronchial tumor.

Fig. 5. Left lung showing massive encapsulation by tumor with compression of the lung. Note the involvement of the diaphragmatic surface.

The liver weighed 2,300 gm. and was en-

larged as a result of multiple metastatic tumor nodules varying from 1 up to 3 cm. in diameter. These were present on the capsular and cut surfaces and were grayish-white in color. A few possessed umbilicated centers.

The gallbladder was grossly normal; the bile ducts were patent.

The spleen weighed 245 gm. and was enlarged and firm. Its capsule presented several

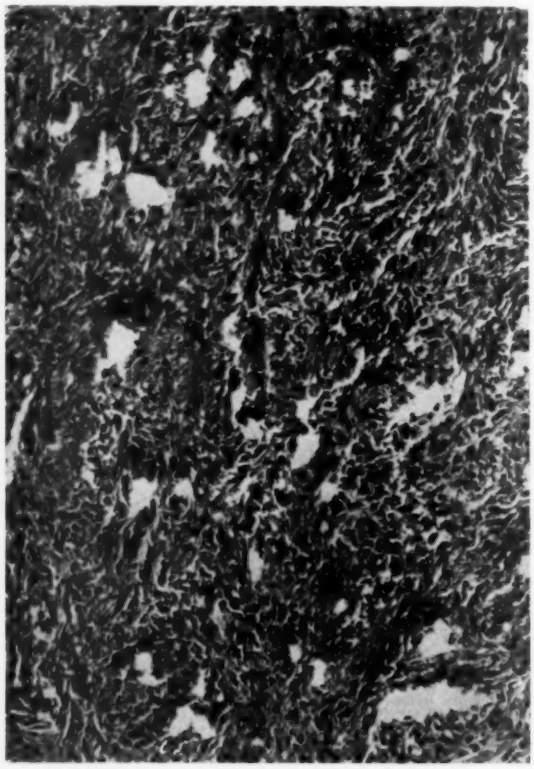

Fig. 6. Low power view of pleural tumor showing interlacing bundles of collagen-producing cells, thus warranting the evaluation of pleural mesothelioma. 200×.

tiny, pin-head sized tumor nodules. The parenchymal tissue was firm and purple red in color.

There was metastatic tumor in both adrenals with destruction of a little more than half of the medullary and cortical tissues. There was not sufficient tumor replacement to warrant the diagnosis of Addison's disease.

The kidneys showed metastatic tumor nodules in the cortical areas, but these produced little disturbance of the parenchymal tissue. The capsule of the left kidney at its upper pole was invaded by tumor. The pelvic mucosa, ureters and urinary bladder were grossly normal.

The gastrointestinal tract was normal except for distention. Scattered throughout the omental, mesenteric and retroperitoneal fat there were several tiny shotty tumor nodules, each of which averaged 1 mm. in diameter.

The pancreas was grossly normal.

Permission to examine the head was refused.

The gross diagnosis at the autopsy table was pleural endothelioma with multiple metastases to lungs, ribs, liver, adrenals, kidneys and peritoneum.

Microscopic study of the pleural tumor (Fig. 6) and of its metastatic foci shows a similar pattern so that all regions will be described together. The neoplasm is composed of interlacing bundles of spindle cells which form collagen. The latter varies in appearance, being dense and hyalinized in some sections. The nuclei possess fine vesicular chromatin markings and indistinct nucleoli. Where cut in cross-section the nuclei are oval or spherical. There is no attempt at palisading. The neoplastic cells are fairly uniform in size, shape and staining quality for the most part, although there are areas, particularly in the metastatic foci, where pleomorphism and hyperchromatism are encountered. Unbalanced mitotic figures are infrequent. Tumor giant cells with two, three or four nuclei are not infrequently seen. The tumor varies in cellularity. The more cellular areas are identified in the metastases The tumor does not have the pattern of the usual pleural endothelioma. It is true that the nuclei are pale and vesicular, but the component cells appear to be producing collagen rather than endothelial-lined spaces, which would suggest that the neoplastic elements are derived from the supportive stroma of the pleura itself or from the supportive tissue of its contained vessels However, since the primitive endothelial cell and the fibroblast are a product of the mesenchyme, it is not surprising to see the above variations. In view of this cytology the diagnosis of pleural mesothelioma rather than endothelioma seems more tenable and more easily defended.

PATHOLOGY

According to Klemperer and Rabin[2] primary neoplasms of the pleura are of two main types. One is primarily localized in one part of the pleura. It comprises many histopathologic types and includes both benign and malignant forms. These tumors

originate from the tissues beneath the superficial lining cells. The other type (mesothelioma) is of a diffuse nature that involves the entire pleura (both visceral and parietal pleurae in our case). Usually the entire lung is ensheathed with tumor tissue (Fig. 5). This type probably arises from the visceral pleura.

Robertson[5] states that in mesothelioma, "the pleural surfaces . . . in whole or in part, are either studded with discrete nodules, or diffusely thickened by a greyish-white growth which is often very dense and tough. The cavity separating the visceral and partietal layers practically always persists and contains hemorrhagic fluid". In our case the fusion of the visceral and parietal pleurae by tumor tissue explains the absence of the pleural effusion which is usually observed.

SUMMARY

1. The roentgen diagnosis of pleural mesothelioma, as previously reported, has emphasized the findings of pleural effusion (usually massive), with or without tumor nodules.

2. The pathological anatomy of pleural tumors is briefly outlined.

3. A case is presented where the roentgenograms show only gross pleural thickening without evidence of effusion or pleural or parenchymal tumor nodules.

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TISSUE NECROSIS FOLLOWING PERIVESICAL EXTRAVASATION OF UNDECYLATE EMULSION CONTRAST MEDIUM

CASE REPORT

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THE use of various contrast media to delineate the urethra and urogenital sinus in pseudohermaphroditism is a common diagnostic procedure. A recent mishap following extravasation of sodium ethyl iodo undecylate emulsion, 50 per cent aqueous suspension, indicates that this material is unsafe if extravasation occurs and suggests that a less irritating, water soluble radiopaque material should be used.

CASE REPORT

D.P. (J.H.H. No A-69925), a child, aged one and a half, with genetic intersexuality (male hypospadias and a urogenital sinus), was admitted to Johns Hopkins Hospital on the service of Dr. Lawson Wilkins for investigation to rule out female components. On April 21, 1949, under ether anesthesia, cystoscopy was carried out. The diagram (Fig. 1) indicates the anatomical relationships. At the end of this procedure a combined cystogram and attempted roentgenographic demonstration of the urogenital sinus was carried out with skiodan in the bladder and undecylate emulsion injected into the sinus through a urethral catheter.

Presumably due to instrumental trauma the undecylate emulsion extravasated retrovesically. This condition was not recognized at once because the cystogram partially obscured the extravasated material. The next day the child developed fever (40° C.) and leukocytosis, and a marked abdominal tenderness and rigidity were demonstrable. This seemed to be limited to the lower abdomen, however, and it was thought that the extravasation was extraperitoneal. Figure 2, a right oblique view, reveals the appearance of the extravasated material at this time.

After observation for five days, during which the white blood cell count rose to 17,700 per cu. mm., and the temperature spiked daily, it was decided to perform an exploratory laparotomy and to drain the area of extravasation. This was carried out on April 26, 1949. Figures

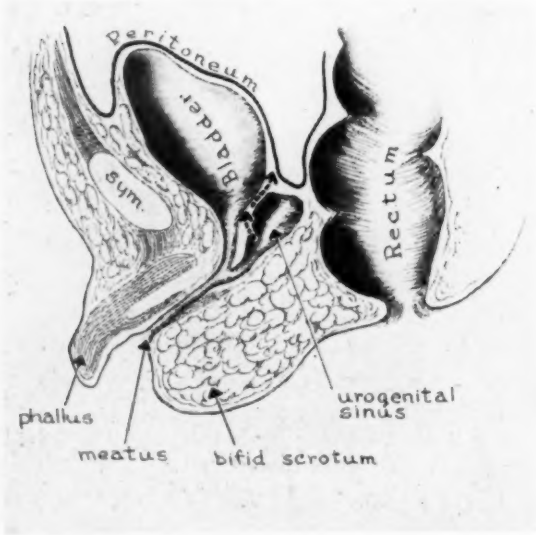

FIG. 1. Diagram showing anatomical relationships.

FIG. 2. Right oblique view showing appearance of extravasated material.

Fig. 3 and 4. Roentgen appearance before exploration.

3 and 4 show the roentgen appearance before exploration.

When the peritoneum was opened it was found to contain a few cubic centimeters of serosanguineous fluid. One loop of small intestine was adherent anteriorly to the peritoneum in the retrovesical area. There was a butterfly-shaped area of peritoneal necrosis, which appeared yellowish with reddened edges in the whole region behind the bladder. The intestine was gently dissected from the adhesion to the peritoneum and found to be intact though inflamed on the surface. There was no sign of uterus or ovaries. The peritoneum was then closed. Gentle dissection was then carried downward, extraperitoneally and laterally, between the posterolateral edges of the bladder and the peritoneum. This whole area was found to be necrotic, yellow, and edematous. Penrose drains were placed deeply in the wound on both sides, and the incision was closed.

Fig. 5. Roentgenogram showing the gradual absorption of the extravasated material twenty-three days postoperatively.

Fig. 6. Roentgenogram taken on October 4, 1949, shows complete disappearance of contrast medium.

The postoperative recovery was slow and complicated by persistent abdominal tenderness, fever, and leukocytosis (white blood cell count, 25,000 per cu. mm., May 9, 1949, the fourteenth postoperative day). The wounds finally healed, and the fever gradually subsided during the third postoperative week. Figure 5 shows the gradual absorption of the extravasated material as demonstrated roentgenographically, twenty-three days postoperatively.

The child was finally discharged, and his condition has progressed satisfactorily at home. A recent film (October 4, 1949, Fig. 6) shows complete disappearance of the material. There is no apparent residual damage.

SUMMARY AND CONCLUSION

A case of inadvertent retrovesical extravasation of undecylate emulsion contrast medium, used in an attempt to demonstrate a urogenital sinus, is described. The patient suffered a severe febrile response with leukocytosis. The peritoneum and perivesical regions touched by the material became necrotic as seen at surgical exploration and drainage of the area.

It is concluded that the use of this or similar tissue-damaging materials as roentgenographic contrast media when extravasation may occur is potentially dangerous, and that a water soluble, less irritating radiopaque material should be used.

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CYSTIC HYGROMA OF THE NECK AND MEDIASTINUM SUCCESSFULLY TREATED BY ROENTGEN RAYS*

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THESE tumors are rare and the records of treatment by irradiation are even more rare. This is our reason for making this report. Nearly all cases have formerly been treated surgically, but the dangers and fatalities from infection or hemorrhage have led to the investigation of the value of radiation therapy, which seems to be producing superior results with little or no danger.

Figi of the Mayo Clinic, in 1939, said, "The treatment of multilocular lymph cysts, or cystic hygromas of the neck has in the past been considered surgical."

The rarity of the condition is indicated by the fact that Figi reported at that time "only thirteen cases of cystic hygromas of the neck in infants and children had been seen in the Mayo Clinic during the last 10 years (1918–1927 inclusive). Because of the extent of the tumor, excision was considered advisable in only one. Radium was used in the remaining twelve."

The fact that only 13 cases were seen in the Mayo Clinic in ten years and only one of these was found suitable for surgery indicates pretty definitely that we must find some other form of treatment. *All authors seem to agree that if the disease has invaded the mediastinum, as in our case, surgery must be excluded.* One of Figi's 13 cases had been previously reported by New of the Mayo Clinic and was the only one found, in the previous literature, which had been treated by radium.

The etiology is unknown but several theories have been discussed by previous authors, and will not be reviewed by us. Figi says, "True cystic hygromas of the neck are rare. They are usually soft, semifluctuant, freely movable tumors on the side of the neck, in some cases extending onto the face, or into the axilla. They are sometimes pedunculated. The overlying skin is usually normal in appearance, although it may be tense or stretched, due to the large size, superficial location, or weight of the tumor. The mass may be as translucent as hydrocele of the testis."

"Most of the patients with tumors of this type are infants, and young children."

Reports are found in the literature that a cure at times follows infection of these hygromas, and infection may involve one cystic cavity and not the others, but Figi says, "I have not observed a case in which the growth disappeared spontaneously following an acute inflammatory process; acute infection of the mass resulted fatally in seven of the series of thirteen cases."

A positive clinical diagnosis can usually be established readily. In fact, it was extremely simple for one of us (Pfahler) because when the child (aged twenty months June 24, 1944) was asked, "What is the matter?" he answered, "I have a hygroma." The diagnosis had been made by the junior author but we were deeply impressed with the glibness with which this child referred to his diagnosis.

A differential diagnosis must be made from the following:

1. *Branchial Cyst.* This is a branchial remnant usually present at birth. Cysts originating in branchial clefts are more apt to be single than multilocular, oval or round in shape and smaller than hygroma. Branchial cysts are definitely circumscribed, quite firm and tense. They usually occur in the anterior triangle of the neck. The skin overlying branchial cysts is not thinned as is the case with hygroma. A branchial cyst is usually located along the anterior border of the sternocleidomastoid muscle while a cystic hygroma is found most often in the lower half of the neck.

* Presented before the Philadelphia Roentgen Ray Society, Philadelphia, Pa., March 3, 1949.

2. *Solitary Lymph Cyst.* A solitary lymph cyst is most frequently found in the supraclavicular region, and is translucent to illuminated light. It appears in adults. It is a fluctuant soft deep-seated tumor and does not transmit light.

3. *Lipoma.* A lipomatous tumor grows less rapidly than a hygroma and upon aspiration does not yield any fluid.

4. *Thyroglossal cysts and fistulas* occur primarily in the midline of the neck, most commonly in the upper half, and are usually associated with a subcutaneous cord, etc.

5. *A deep-seated hemangioma* may be differentiated from a cystic hygroma by the simple test of pressure which causes the hemangioma to be reduced in size and refills again when the pressure is removed.

6. *Tuberculous lymph nodes* are characterized by the signs of local inflammation and after a time become matted together and, with the overlying skin, caseate and break down with a discharge of pus. Non-tuberculous enlarged glands are secondary to infections of the nose and throat, are discrete, tender, and freely movable beneath the skin.

TREATMENT

Figi says that at the Mayo Clinic, prior to 1918, all cysts of the neck were treated surgically but the results were rather unsatisfactory, and says that with reference to *those which extend into the mediastinum, excision is not feasible.* Since 1918, radium has been used almost exclusively in The Mayo Clinic.

We are referring in much detail to the report from Figi because it represents the largest experience on record in the treatment of hygromas by radium.

Radium Technique. "In 12 of the 13 cases radium was used as part of the treatment. In the Clinic, the radium was administered directly over the tumor at a distance of 2.5 cm., with screening of 2 mm. of lead. Topical applications only were made; from 3,000 to 7,000 mg.-hr. of radium were administered at each treatment, and the application repeated at intervals of from two to three months. If the growth was acutely inflamed the applications were less intensive. Each patient was given from one to nine treatments; the average was about four. Since some of the patients received radium treatment elsewhere subsequently, these figures are only approximate. Three of the patients thus treated are now entirely well."

In the closing discussion, Figi says, "Radium treatment would not be likely to have any effect on a branchial cyst."

"Malignant degeneration has not occurred in any of the cases of cystic hygroma seen in the Clinic and I have seen no report in the literature of its occurrence."

Hodges, Snead and Berger have published an excellent paper on "Roentgen Therapy of Cystic Hygroma of the Neck in Children." They state that Vaughn, Dowd, and MacGuire in separate studies of the literature up to 1935 found 163 recorded cases with only 19 in adults. In 1938, Fleming added 2 fully developed cases in adults. These authors[4] make a report on 7 cases of hygroma treated by roentgen rays, 4 with excellent results, 1 a fair result, and 2 failures. One failure was in a boy nine years of age, and another in a girl eleven years old. In these 2 latter cases, the growths had been noticed since birth. *In only 1 of the 7 cases reported did the disease extend into the mediastinum* but this extension was very great and there was extension also into the coracoid and left axillary region. This remarkable case showed complete recovery within a period of approximately two years.

The following factors were used in the treatment of their cases: 125 to 130 kv., 6 mm. Al filter, 10 to 12 inch distance, and once a month a dose of about 100 to 150 r, measured in air, was administered to the entire growth.

These authors[4] give the following advice:

"We believe this treatment, on account of the better cosmetic results which can be obtained and its lack of danger, should be tried before resorting to other methods in all cases except the very thin-walled, well-circumscribed, cystic types which can be easily excised."

"These growths should be treated when

first noticed since here, as in angioma and keloid, the early stage of development seems to be much more radiosensitive. Also many grow more or less rapidly and later a much larger area may have to be irradiated."

Portmann[7] reports on 3 of the 7 cases of cystic hygroma seen at the Cleveland Clinic.

Case 1 was a baby girl, aged ten months, who had progressively enlarging masses on either side of the neck below the mandible. The masses were pressing into the floor of the mouth. The inside of the mouth had been incised at the age of six weeks without benefit. She had dyspnea and difficulty in taking nourishment.

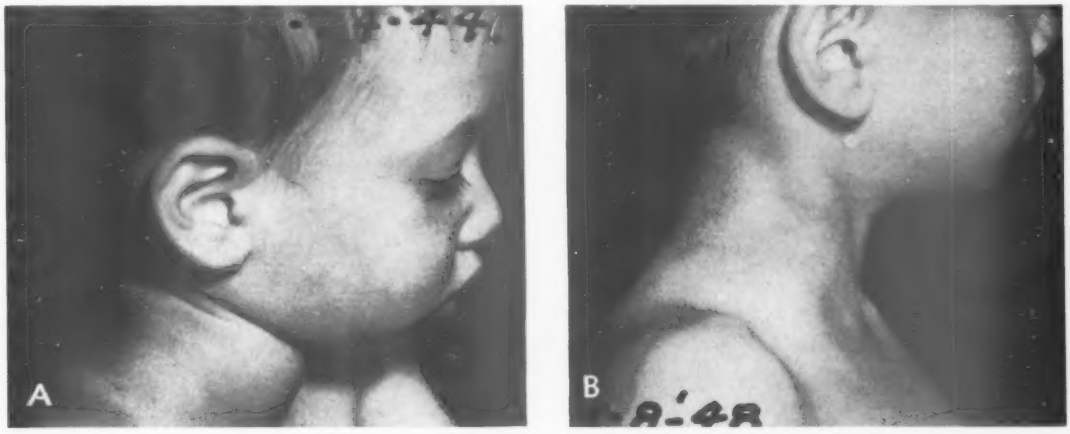

Fig. 1. (*A*) June 24, 1944. Showing the hygroma projecting in the neck, and this extended down into the mediastinum, evidently caused some pressure on the carotid veins, or perhaps even of the descending vena cava. (*B*) May 8, 1948, or approximately two years later, the child was practically well, though there was a slight fullness remaining at the base of the neck. Today, or approximately four years from the beginning of treatment, he is entirely well with no interference with his growth, damage to his skin, or any lack of mental development.

The child was given a trial treatment with roentgen therapy, with 100 r over a 10 by 10 cm. square field weekly for six weeks. The cervical masses began to diminish in size. When she returned for further treatment, the child had a fever which followed vaccination a week previously and it was decided to defer treatment until the fever subsided. A few weeks later, the child was taken elsewhere to a surgeon, who attempted to remove the tumors, in spite of extensive inaccessible mediastinal involvement. Later, a second and more radical operation was attempted on the other side and uncontrollable hemorrhage resulted in immediate death. The pathologist's diagnosis was cystic hygroma.

Case 2, a baby boy, aged two, was born with a cyst the size of a walnut on the right side of the neck. Following a blow on the neck, the cyst enlarged rapidly. A roentgenogram showed a substernal mass connected with the tumors in the neck. The infected area was incised and drained. Several weeks later the cyst was found to involve the carotid sheath and to extend high up *posterior to the trachea and downward into the mediastinum* in close proximity to the large vessels. Fourteen radon seeds were inserted, each 1.4 mc. (filter 0.3 mm. gold). Infection occurred after the operation but the child recovered and had no recurrence in nine years.

Portmann's third case was a baby girl, aged five weeks, who was born with "puffiness" at the left side of the neck, arm and lateral chest wall. Examination revealed lobulated tumor masses filling the left supraclavicular fossa and axilla and extending down to the elbow and over the entire chest wall from sternum to axilla. The rubbery consistency of the masses was characteristic of cystic hygroma. Operation was considered inadvisable, and local therapy was instituted. The technical factors employed were 200 kv., filter equivalent to 0.9 mm. half-value layer copper, 50 cm. focus-skin distance; 100 r, measured on the skin, through portals 10 by 10 cm. square, was given at weekly, and later at monthly intervals for approximately two years, but as nearly as could be estimated each part of the tumor mass received approximately 1,200 r during this time.

There was progressive reduction in size of the tumor masses and only remnants remained above the elbow. At two and a half years of age, the child was normally developed without apparent interference with bone growth or muscle function.

This third case reported by Portmann is one more that can be added which was definitely treated by roentgen rays and

good results obtained. It seems advisable to record these results as they occur in order to accumulate enough good results to justify our concluding that roentgen therapy is probably the best form of treatment for cystic hygroma of the neck, and certainly when the mediastinum is involved.

One of us (Pfahler) has been using roentgen therapy for approximately fifty years and radium during approximately thirty-eight years (during twenty years, he has had 1,250 mg. of radium element available), but theoretically it would seem that roentgen radiation is more appropriate for treatment of these hygromas than radium, for the following reasons: (1) the roentgen rays can be directed precisely where they are desired and one can protect almost completely the surrounding tissue, while when radium is used it is impossible to keep the rays from spreading their effects in a case of this kind to the surrounding tissues, all of which can be damaged by any large amount of the radiation. Even with the roentgen rays, one must keep in mind, first of all, the avoidance of damage to the neighboring tissues or organs; (2) because of the distance, 50 cm. as compared with 2.5 cm., and using either low voltage rays, 125 kv. (Hodges) or high voltage rays 180 kv. (Pfahler) it gives a greater depth value in these tissues and yet a relatively similar effect in all of the tumor tissue involved as compared with the local application of radium; (3) the roentgen rays are much more widely available and more radiologists are familiar with the therapeutic technique used, especially when dealing with deep-seated tissue.

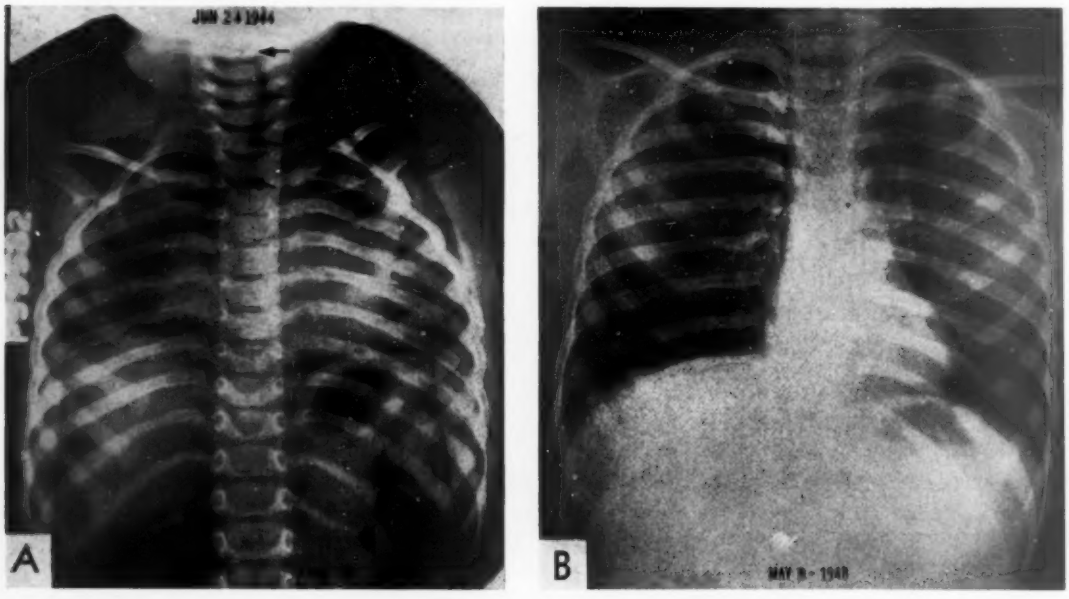

Fig. 2. (*A*) June 24, 1944, shows the displacement due to pressure of the tumor upon the trachea, and extending down into the mediastinum. (*B*) May 8, 1948, shows a normal chest in every respect.

CASE REPORT

This child was first seen by one of us (H. H. P.) twelve days after birth. He had a moderate-sized umbilical hernia, which yielded to treatment, but there was nothing found at that time nor in the subsequent care of the child that has any bearing upon the hygroma, which concerns us at the present. At the end of the first year, a small swelling was found on the right side of the neck which the mother attributed to paroxysms of coughing, and this swelling became more pronounced when the child cried. The mother paid no attention to this condition until she brought him to the

pediatrician (H. H. P.) at thirteen months of age.

At that time he found a mass, soft and noncompressible, the size of a small plum, involving the right side of the neck. When the child cried, it became larger and protruded slightly above the right clavicle. A diagnosis of hygroma was made and the patient was admitted to the Jewish Hospital under the care of Dr. Block, who confirmed the diagnosis of hygroma. A roentgenogram made January 7, 1944, by Dr. Leon Solis-Cohen at the Jewish Hospital showed "a circular shaped soft tissue mass above the right clavicle. No abnormal changes are seen in the clavicle or cervical spine."

During the next five months the mass of the tumor continued to grow in size until the patient was twenty months old (June 17, 1944) when there existed a cystic mass the size of two hen's eggs that filled the right supraclavicular region and right side of the neck, and although translucent to artificial lighting, it was easily compressible, but returned to its proper size upon release of pressure by the examining finger. The patient was then referred to the senior author for roentgen examination and treatment.

Because of the enlarged veins on the anterior surface of the chest, we suspected mediastinal involvement with pressure upon the descending vena cava. Instantaneous roentgenograms of the chest were made posteroanteriorly and laterally. These showed very definite displacement of the mediastinal tissues in relation to the spinal column. In addition to this, there was shown a fuzzy mass surrounding the entire shape of the heart, and extending within 2 cm. from the left wall of the chest, and 4 cm. from the right wall of the chest. This abnormal tissue in the mediastinum was not sharply defined. One would expect it to be if it were part of the cyst, but, on the other hand, we have no other explanation for this condition except that it was in some way connected with the cystic tissue in the right supraclavicular region. The lateral views of the chest did not show any compression of the trachea in the anteroposterior direction, and no appreciable dense mass in the mediastinum. Because of the mediastinal involvement, operation was out of the question.

Roentgen treatment was begun July 5, 1944, using high voltage rays, 180 kv., 15 ma., 27 r per minute, 50 cm. distance, using 0.5 mm. Cu—1 mm. Al filtration, with 150 sq. cm. portal, and giving 300 r per dose. Three portals were used—one right anterior neck and chest; one posterior neck and chest, and one through the right axilla. All roentgen-ray beams were directed toward the mediastinum. These treatments were given serially on July 5, 18, 25; August 8, 30; September 13, October 11, November 22, 1944, which equals a total of eight treatments in five months, or a total surface dose of 2,400 r, measured in air. He received three treatments in 1945, January 3, February 8, and September 22. He received his final treatment March 23, 1946, or a total surface dose of 4,000 r. It was estimated that 50 per cent, or 2,000 r, reached the deep parts of the tumor.

Progressive reduction was noticed by us. On May 23, 1945, we estimated that only about one-fourth of the tumor tissue remained. At the original roentgen examination the trachea had been displaced to the left, approximately 12 mm. On May 23, 1945, it was about 5 mm. to the left of the median line. The lung area had increased normally.

This patient has been examined from time to time since his last treatment on March 23, 1946. He was re-examined on February 5, 1949. There was no visible or palpable disease anywhere. His skin was normal. There was no interference with his growth. He was entirely symptom free. He is attending school and his progress is reported to us as being favorable.

Roentgenograms of the chest both posteroanteriorly and laterally showed nothing abnormal. We therefore have a right to consider this case a cure without any serious risk and without any damage.

CONCLUSIONS

We believe that roentgen therapy should be given the first consideration in the treatment of cystic hygroma. If for any reason operation seems advisable, the amount of treatment estimated to be necessary by us should not interfere with any operative procedures that seem advisable. Operation when the mediastinum is involved should not be considered. This is indicated by Figi's experience at the Mayo Clinic where only one of thirteen cases was considered suitable for operation. The experience on the part of Figi, Portmann, Hodges *et al.*, as well as our own experience, seems to

indicate the line of treatment in this rare condition.

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HEMANGIO-ENDOTHELIOMA OF THE PELVIS

RESPONSE TO IRRADIATION

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BECAUSE hemangioma of the pelvis is uncommon, knowledge concerning its treatment will be mainly obtained through individual case reports. The following case represents a twelve year cure by irradiation. A search of the literature reveals only one case treated with radiation therapy, with a six year follow-up.[3]

REVIEW OF LITERATURE

The first case of hemangioma of the uterus was reported by Klob[4] in 1864.

In 1906 Horië[2] reported a case arising on the anterior wall of the uterus in a patient, thirty-five years of age. The uterus was considerably enlarged and contained black tar-like blood. Surgical difficulty being encountered, the patient was closed without further interference.

Pantzer,[5] in 1911, reported a case in a patient, twenty-six years of age, where hemangioma was found to be in the peritoneum in front of the uterus, with involvement of the right half of the bladder and fallopian tube. The right uterine artery was ligated to avoid hemorrhage from surgery in face of the marked vascularity.

A case operated on by Dr. T. S. Cullen was reported by Wright[6] in 1926. Here again the tumor had involved the uterus and broad ligament. Surgery was limited to supravaginal hysterectomy because of marked hemorrhage encountered at operation.

Apparently the pathology in hemangioma of the pelvis is not localized to a particular organ or region, making the surgical approach extremely difficult or impossible.

Horgan's[1] excellent review of the literature in 1930 brought the number of reported cases to 20, including the above. Kevorkian,[3] in 1940, reported the first case treated with irradiation. Our case brings the total number reported to 39 and the second favorable response to roentgen irradiation.

CASE REPORT

Mrs. I. M., aged twenty-eight, was first admitted to St. Luke's Hospital, Kansas City, Missouri, April 3, 1936, complaining of abdominal pain. She stated that she had had three previous episodes of abdominal pain originating in the epigastrium and radiating to the right lower quadrant. General soreness over the abdomen followed the above initial attacks, progressing to such a degree that she was incapacitated the day following the acute episode. The first attack occurred in January, 1936, and the second two weeks prior to her hospital admittance. The third attack, April 2, 1936, forced her to seek medical aid.

The menstrual history revealed that for the past five months she had had scanty irregular flow associated with dysmenorrhea.

The pertinent physical observations related to the history were as follows:

An indefinite mass was noted on the left side extending from the anterior iliac crest to the midline of the abdomen. She complained of severe pain when the mass was manipulated. Marked tenderness was noted in both adnexal regions and although the uterus did not feel unduly large it was "frozen" in its position with thickening of the broad ligament.

The preoperative impression was: ovarian cyst, left; salpingitis, left; possible subacute appendicitis.

At operation a large irregular vascular mass was readily evident distorting the left broad ligaments and overlying the sigmoid colon. In the opinion of the surgeon, he was able to remove the entire tumor.

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† Radiologist, Menorah Hospital.

The pathological report by Dr. Ferdinand Helwig* revealed the following:

Gross Pathology. The specimen is a fairly well encapsulated nodular tumor mass of very irregular outline measuring 10 by 6 by 7 cm. It has a generally brownish coloration with many nodulations ranging from a light yellow to a deep bluish black color. On cross section varying size hemorrhagic, cystic, and solid areas are seen as well as areas of glistening hyaline character. Numerous areas of necrosis are likewise encountered, some of which are hemorrhagic.

Histologic Pathology. Sections (Fig. 1) show wide areas of hyaline material in which are

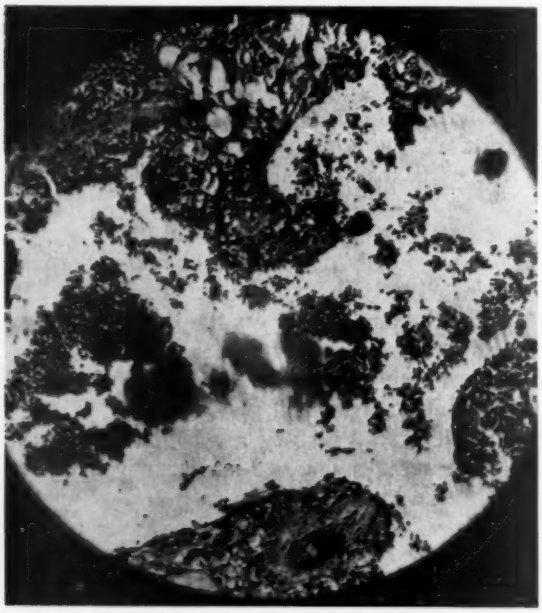

Fig. 1. Photomicrograph of section taken from tumor.

imbedded small spindle and round cells. Occasionally blood vessels are seen which, in many instances, are completely surrounded by this hyaline material. Here and there focal areas of mucinous degeneration are encountered and occasional widely dilated vascular channels are observed surrounded by spindle cells. In other areas, the tumor is unusually cellular. Mitotic figures are occasionally encountered. The tumor cells for the most part are vesicular and show moderate variation in size and shape. The large vascular channels are often lined by swollen rows of endothelial-like cells and some of the cells are seen projecting into the lumen of these channels.

Diagnosis: Hemangio-endothelioma of the broad ligament.

Comment by Dr. Helwig: It is my opinion that this tumor is of low grade malignancy and will recur locally. Excellent encapsulaton and extensive hyaline changes suggest that it is a relatively slowly growing process but there are focal cellular areas which very strongly suggest it may be a tumor which will metastasize. I think the prognosis should be very guarded."

Two weeks following the operative procedure, the patient was dismissed from the hospital. For two months there was a complete remission but pain recurred in a most severe and excruciating attack, of such severity that she insisted on a second operative investigation.

Communication with one of the surgeons† who assisted at this operation disclosed that the entire pelvis was filled with nodular hemorrhagic areas. The pelvic organs were completely distorted with the cystic vascular areas extending outward along the broad ligaments, the ovaries, and the uterus. The futility of any surgical intervention was realized and a small nodule was removed for biopsy. The tissue removed was as described above by Dr. F. Helwig. Dr. Robert Koritschoner‡ at Menorah Hospital concurred in the diagnosis of hemangio-endothelioma.

As a last resort the patient was referred to the Tumor Clinic at Menorah Hospital, where it was decided to give radiation therapy in the hope of obtaining some palliation. Roentgen therapy was started on November 23, 1936.

The technique employed was as follows: 200 kv. (peak), 20 ma., 1 mm. Cu plus 1 mm. Al filtration, at 80 cm. distance, half-value layer 1.425 mm. Cu (9.16 r per minute in air). The daily dose was 100 r. The pelvis was divided into two anterior, two posterior and two lateral fields, 15 by 15 cm. The two opposing fields were treated daily until 2,000 r had been delivered to each. The estimated depth dose to the center of the pelvis (both right and left sides) was 4,610 r. Treatment was completed on March 6, 1947. The total treatment period was approximately three and a half months.

The patient was observed for a period of

* Pathologist at St. Luke's Hospital, Kansas City, Missouri.

† Dr. P. C. Quistgard, staff member at St. Joseph Hospital, Kansas City, Mo.

‡ Deceased, November 15, 1948.

several years following the roentgen therapy and then did not return to the clinic until November 8, 1948, *an interval of eleven years.* There had been a recurrence of pain, moderate in severity, for which she again sought relief. Examination at this time revealed a somewhat movable and normal sized uterus. The right parametrium was pliable but there was induration on the left extending a few centimeters out laterally in the broad ligament. She experienced severe pain when this area was palpated.

Because of the excellent tumor response to irradiation, it was decided that another cycle was justified; however, the total dose was reduced. The factors were as follows: 250 kv. (peak), 15 ma., Thoraeus-2 plus 1 mm. Al filtration, half-value layer 2.8 mm. Cu, 50 cm. distance; 150 r, in air, was given daily to two alternate fields after dividing the pelvis into two anterior and two posterior fields measuring 12 by 15 cm. A total of 1,050 r was administered to each field. The estimated depth dose to the mid-pelvis on either side was 1,148 r.

The patient was examined three months later and both parametrial regions were soft and pliable. No tenderness was elicited with palpation at this date. Since she was asymptomatic and in view of the negative pelvic findings she was advised to return to the clinic at six month intervals. Roentgenograms of the chest, spine, pelvis and skull revealed no evidence of metastatic involvement.

SUMMARY

1. Because hemangio-endothelioma of the pelvis is uncommon, knowledge concerning its treatment will be mainly obtained through individual case reports.

2. The pathological process in hemangioma of the pelvis is not localized to a particular organ or region, making the surgical approach extremely difficult or impossible.

3. A case is reported with a twelve year cure by irradiation (only one other case[3] reported as having been treated with radiation therapy was found in the literature).

4. The technique of the roentgen therapy is described.

5. Apparently hemangio-endothelioma of the pelvis should be added to the list of radiosensitive tumors.

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DIRECT SERIAL ROENTGENOGRAPHY IN TWO PLANES SIMULTANEOUSLY AT 0.08 SECOND INTERVALS*

PHYSIOLOGICAL ASPECTS OF ROENTGEN DIAGNOSIS; THE APPARATUS AND ITS APPLICATION TO ANGIOCARDIOGRAPHY

By GEORG FREDZELL, JOHN LIND, ERIC OHLSON *and* CARL WEGELIUS

STOCKHOLM SWEDEN

PHYSIOLOGICAL ASPECTS

IN GENERAL, roentgen examination has been employed for the determination of the size, morphology and topography of the internal organs. The dynamics of these organs, insofar as it has attracted interest, has been especially studied only by means of roentgenoscopy. A number of organs have, however, no fixed morphology "in vivo," but, on account of their dynamics, vary considerably both as to shape, size and position. To some extent, attempts at making the roentgenographic exposures at predetermined phases during the dynamic process have enabled us to form an opinion of this process. Such separate, isolated, ever-changing pictures of a continuous movement cannot, however, reveal the continuity of such a process.

The problem of roentgenographically recording dynamic phenomena in the internal organs can be solved in principle by repeated roentgenograms, but only if the film sequence is sufficiently rapid to follow the movements in question in all their phases. The technique of obtaining a series of rapid exposures has been developed recently as a result of the demand for a quick sequence of angiocardiograms, a method of examination which is becoming increasingly important. Angiocardiography has not as yet been directed to any extent to following the dynamics of the heart chambers and the larger blood vessels, but has in the first place been concerned with morphological changes, anomalies and abnormal communications which are of importance to cardiological diagnosis and surgery of the heart. The necessity of obtaining a fast film sequence has been especially dictated by the need to record roentgenographically the momentary visualization of the heart chambers as they are filled by the very rapidly flowing medium.* The technical development to this end has, however, at the same time led us forward a step farther on the road which will also make possible studies of the dynamics, in addition to the morphological and topographical aspects which are so important in themselves.

Our task has been to state, in principle, the demands made on a technique which will satisfactorily solve the problem of roentgenological recording of dynamic processes, and, with the resources available, to show the possibilities of making those demands practicable by the construction of an apparatus suited to them. In the present paper, we have elected to show the adaptation of the method to angiocardiography.

SPECIAL REQUIREMENTS FOR DYNAMIC RECORDING BY ROENTGENOGRAPHY

The starting point for our attitude towards the problem of the necessary rate of exposure for recording the dynamics of the heart has been to discover at what speed film sequence will guarantee the roentgenographical recording of the different heart chambers at maximum systole and diastole. In order to judge the working of the heart as a whole, these two extremes must be visualized, and the manner in

* See references.

* From Norrtulls Hospital (Chief: Professor Arvid Wallgren) and the Schönander Research Department, Stockholm, Sweden.

which the passage from one to the other is made can then be followed from the intervening films. Recognizing the importance of angiocardiography in the early diagnosis of congenital heart defects in infants, we have considered it necessary for our apparatus to be able to record the dynamic processes of the heart even at the fast heart rate of these infants. If this requirement is fulfilled, the rate of exposure will certainly be sufficient to record the slower heart frequencies of older children and adults.

In the angiocardiography of infants, it is necessary to reckon with a heart rate of 120–200. If we take such a high figure as 180, it implies three complete heart cycles per second. We assumed for practical purposes and on account of its simplicity, that the ratio between the auricular systole and the auricular diastole at this frequency is about 1:2 and between the ventricular systole and the ventricular diastole about 2:1. In order to catch the auricle and the ventricle both in systole and in diastole we require at least three exposures per heart cycle, i.e. in the frequency under considera- (3 heart cycles per second) a minimum of 9 exposures per second. At this speed one film is obtained of each auricular systole and ventricular diastole, and 2 films of the auricular diastole and the ventricular systole. If the auricle is visualized (by the contrast medium) for two to three seconds, altogether 6–9 films are obtained during systole, and 12–18 in diastole. To allow a margin of safety for possibly higher frequencies, we have chosen an exposure speed of about 12 films per second. The number of films of the auricular systole will now be about 4 per second—if the heart frequency is unchanged (180 per minute). This means that every fourth auricular systole is caught in two exposures. At this speed, we may reckon that both full diastole and systole as well as the intermediate stages between maximum systole and diastole will be roentgenographically recorded, giving satisfactory possibilities for judging the dynamics of the complete heart cycle.

Following the need in angiocardiography for obtaining a rapid film sequence, advances have been made along two paths, direct photography and photofluorography. As we mentioned in a previous work,[7] direct photography is decidedly to be preferred from many points of view. The films are of higher quality, and operation is more convenient. Furthermore, direct photography entails considerably less exposure of the patient to the rays than does photofluorography in its present stage. The large number of films required for dynamic studies entails, in photofluorography, a greater exposure to radiation with the risk of overstepping the margin of safety with harmful effects to the patient, a risk which must be avoided. We note also the fact that American workers, as far as angiocardiography[6,24] is concerned, have lately changed over from photofluorography to direct photography.

In transitory phenomena of the kind in which rapid variations in volume of the different heart chambers occur, *the length of the exposure time* is a factor of great importance. The exposure must not extend beyond a margin of time during which noteworthy changes in configuration and volume of the individual cavities and of their dynamically effective parts may be considered possible, but must be made so short that only a definite phase of the heart cycle is caught on the film. If we again relate this to the problem of angiocardiography of infants with a heart frequency of 3 cycles per second and systole:diastole ratios of 1:2 and 2:1 for the auricle and ventricle respectively, and if we reckon that full systole and diastole in each phase last only for 20 per cent of its duration, *the maximum upper limit for the exposure time in the present case is set at 0.02 second.* In lower heart frequencies, not exceeding 90 per minute, the exposure times may be lengthened to 0.04 second.

A third demand made on roentgenographic recording is that it shall permit *three-dimensional judging* of the cavities (visualized by contrast medium) in the different phases of the heart cycle. With the technique at present commonly used in

angiocardiography, one of the greatest drawbacks of the method may be considered to be the difficulty of localizing the position of the contrast medium in the heart, of identifiying the various chambers of the heart and of forming an opinion of their volume and configuration. Robb and Steinberg[16] (1939), as well as other investigators, have worked with roentgenography in one projection only. If the examination has demanded supplementary views in different projections, the entire examination, with a second injection of contrast medium, has had to be repeated. This has made the procedure of more risk, more laborious, and more time consuming, and has complicated the interpretation of the roentgenograms. It is further virtually impossible by this means to obtain a new series of roentgenograms in the identical phases of the heart and respiratory cycles, and with the identical contrast filling of the various cavities of the heart shown in the first series.

Early in 1946, Axén and Lind[1,2] introduced synchronous serial exposures in two planes at right angles. In collaboration with the Swedish X-ray firm of Georg Schönander, a special table permitting 10 films to be taken in one direction, and 10 films to be taken synchronously at right angles in the course of from five to ten seconds (the speed can be varied), was constructed. This table has since been made available commercially.

Synchronous angiocardiography renders possible a three-dimensional concept of the chambers of the heart. They are projected to the greatest extent possible free of each other, and their variation in capacity and configuration during the heart cycle can thus be appreciated.

The fourth and last demand made on recording of the heart dynamics is *time control.* The relationship of the exposure to absolute units of time must be capable of being recorded for purposes of control, as well as the synchronization of each pair of films (when exposing in two planes). It is also of importance for the differentiation of the phases of heart cycle to combine these films with synchronous electrocardiograms.[1,2] This renders possible an objective appreciation of both the number of exposures per heart cycle and the relation of each individual exposure to the heart cycle, seen from an electrocardiographic point of view.

To sum up, it may be said that roentgenographic recording of the dynamics of the heart makes the following demands on the apparatus employed for angiocardiography: (*a*) a film sequence in direct roentgenography on normal sized film of at least 12 exposures per second, i.e. an exposure interval not exceeding 0.08 second; (*b*) exposure time not to exceed 0.02 second; (*c*) synchronous exposures in two planes at right angles to each other; (*d*) time control for the *synchronous exposures* in relation to absolute units of time and in relation to a simultaneously recorded electrocardiogram.

In order to meet all these demands, we have constructed an apparatus, in the first place for angiocardiography.* The apparatus has been installed at Norrtulls Hospital, and more than fifty angiocardiographic examinations have already been made with it. This apparatus has been developed from an earlier model used for angiocardiography in one plane with an exposure speed of 10 films per second.[7]

SPECIFICATIONS FOR THE APPARATUS

The new apparatus has been constructed so as to make it possible to take 12.5 roentgenograms per second, of a size of 18 by 24 cm., in two planes at right angles. This speed has been selected in order to suit the main supply frequency of 50 cycles per second, and leaves 3 complete cycles between each exposure The length of exposure may be 1 or 2 cycles, i.e. 0.02 or 0.04 second.

The cassette changing devices are incorporated in the roentgenographic table as a single unit (Fig. 1). There are two magazines of cassettes, one in the horizontal plane, and one vertical. The maximum number in each plane is 60 cassettes. By means of a strong spiral spring in the bottom of the magazine, the pack

* This is manufactured by Georg Schönander, Ltd., Stockholm.

of cassettes is pressed against a rotating disc in which there is a radial slit. One edge of this slit is turned down to a distance equal to the thickness of one cassette, and once in each revolution the disc catches the upper cassette in the magazine and places it in a guide. By means of a suitable edge on the upper side of the disc, the cassette is pressed against the steering rims of the guide, and remains completely at rest for more than half a revolution. In this position the cassette is exposed, and during the exposure all the other cassettes in the magazine are protected from radiation by the metal disc itself. Just before the disc engages the next cassette, the exposed one is ejected by a spring wheel into a collecting receptacle. The cassette gear is similar in the two planes, and the rotating discs are synchronously driven by a common motor. On the axle of the horizontal disc, contacts are fitted, which give a starting impulse to the timing device on the roentgen apparatus at the correct instant. Two micro-switches are controlled by the cassettes in the magazines.

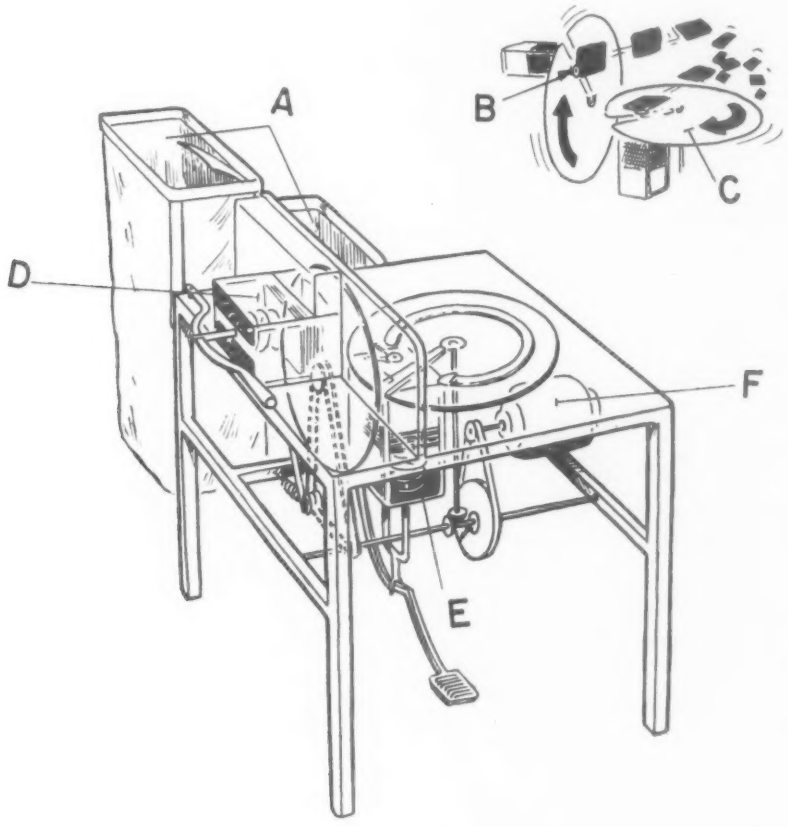

Fig. 1. Cassette changer.
A: Two collecting receptacles for the exposed cassettes.
B: Spring wheel, ejects the exposed cassette into the bag.
C: Rotating metal disc with a radial slit, catches one cassette once every revolution.
D: Magazine of cassettes in the vertical plane.
E: Magazine of cassettes in the horizontal plane.
F: Motor drives the two discs synchronously.

One gives a light signal after 6 cassettes (blanks) for the operator to start the injection, as by now the correct speed of rotation has been reached; the second one opens the exposure circuit, and thereby prevents further radiation when the last cassette has been exposed. Two stationary Lysholm cross-grids are placed just in front of the two cassettes in the exposure position and in the planes of the table.

In order to obtain control of the sequence of the roentgenograms, a cylindrical metal rod is

pictured in both planes just at the joint edges of the films (Fig. 2). This rod is moving toward a fixed tubular index with a constant velocity of 30 mm. per second, and therefore enables a rapid determination of the correct sequence of the films and an estimate of the time elapsing between two roentgenograms to be made. For precise measurements, however, this is not sufficiently accurate, and for this reason a record of a time-scale and of all exposures is made on a synchronous electrocardiogram.

a standard 4-valve generator—the Schönander DIK-1000—and a specially designed control and contactor unit. With an actual resistance of 0.1 ohm on the main power supply, the generator can deliver 800 ma. at 100 kv. (peak), and 1,000 ma. at 85 kv. (peak) to the two parallel-connected tubes. To control this high power, and to connect it to the main supply with the needed precision, it has been necessary to employ an ignitron contactor. The maximum exposure time which can be utilized is 0.04 second,

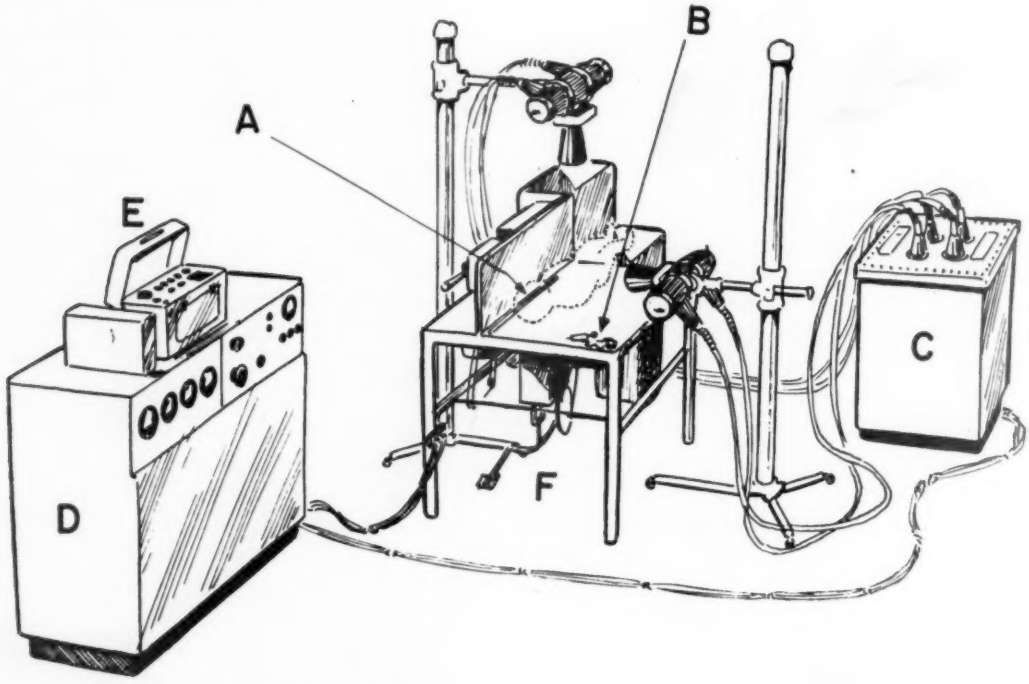

Fig. 2. Complete installation of apparatus.
A: Device controlling the sequence of roentgenograms.
B: Contact for the syringe.
C: High tension generator.
D: Control stand
E: Recorder for electrocardiogram and time scale.
F: Cassette changer.

The cassette (Fig. 3) is made of two sheets of fibre paper, 1 mm. thick, which are glued together along three edges. In this envelope the film is placed between two intensifying screens, and the fourth side of the cassette is closed with Durex tape in a special machine. At the two corners where the rotating disc can pull the cassette out of the magazine, there are metal reinforcing pieces. The weight of the loaded cassette is 0.25 pound.

The roentgen apparatus (Fig. 2) consists of

and in order to obtain uniform times, the velocity of the motor is set at 10 or 12.5 revolutions per second, at which speed the cassettes are still stationary for 0.04 second.

To avoid a discontinuous magnetic state in the high tension generator iron core, and thereby the production of different kilovoltages, the exposures are released at intervals of complete cycles, and then every subsequent exposure in the sequence must occur after a time lapse of two periods. Such accuracy can only be

achieved by electronic devices. The control unit is controlled from the mechanical one by a collector-contact on the axle of the rotating disc, and the starting impulse herefrom connects a peaking transformer to the grid circuit of a thyratron, which in its turn releases the exposure just after the supply voltage has passed zero. This thyratron is connected in series with the ignitor of one of two ignitron tubes, connected in inverse parallel, which together constitute the contactor. The second ignitron is fired from the primary side of the high tension generator via a second thyratron, controlled by the induced voltage of a transformer and phase-shifting network, at the moment when the first ignitron passes current (Fig. 4). The timing device is a condenser discharge circuit controlling the number of peaks from the peaking transformer which is allowed to pass to the firing thyratron.

From the primary terminals of the high tension transformer a signal is carried to the same recorder as the electrocardiogram, and traced on the photographic paper, together with a calibrating sine wave of the supply frequency.

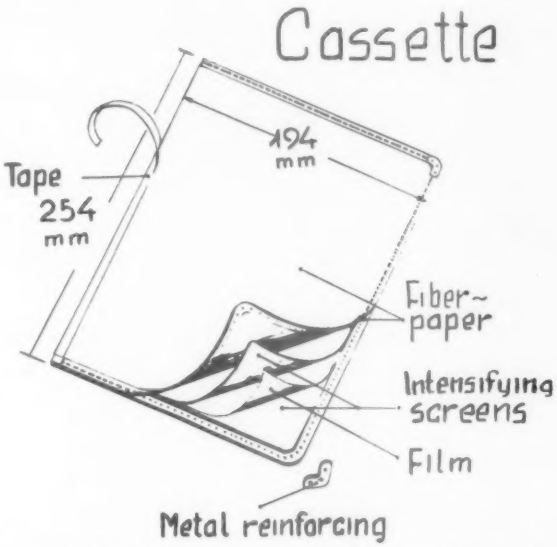

Fig. 3. Cassette. The cassette is closed on the fourth side with a Durex tape. Metal reinforcing pieces at two corners.

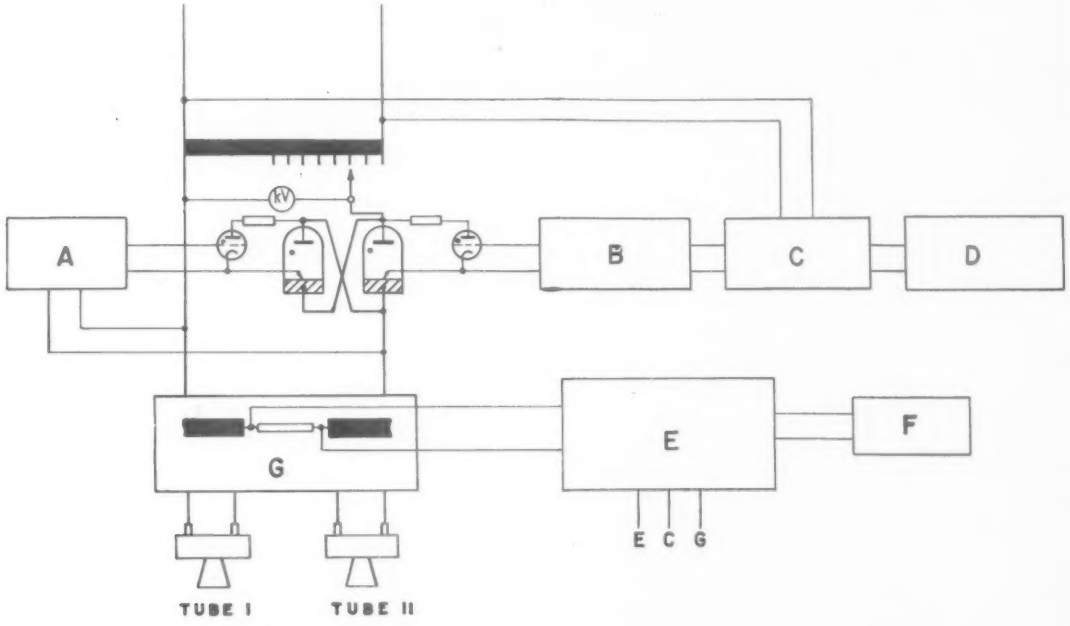

Fig. 4. Electrical components of the apparatus.
A: Grid bias and phase shifting transformer.
B: Condenser discharge timing circuit.
C: Phase shifting network and peaking transformer.
D: Starting contacts on motor axle and protecting contacts in cassette changer.
E: Control instruments and recorder.
F: Syringe contact.
G: High tension generator.

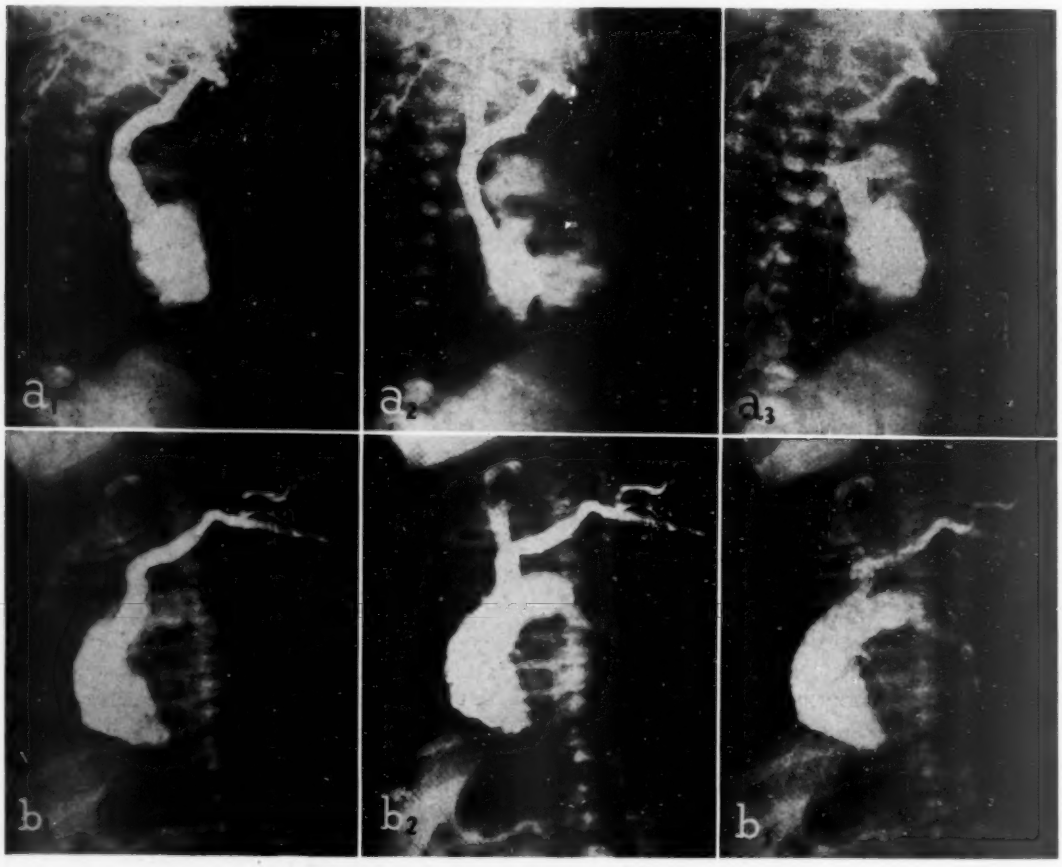

Fig. 5. Visualization of the right heart. Angiocardiograms in sequence with 0.08 sec. intervals. Figures a_1–a_3 in right anterior oblique and Figures b_1–b_3 in left anterior oblique position. A series of angiocardiograms showing the emptying of the right auricle and the right ventricle. The auricle is seen to be biconvex during diastole (a_1, a_3). In systole the piston-like action of the atrioventricular septum causes the latter to compress the blood in the auricular cavity by approximating the septum to the entrances of the venae cavae (a_2). During auricular systole the superior vena cava contracts as a marked diminution in the caliber of the vessel clearly shows (a_2). At maximal ventricular systole only an insignificant amount of blood remains in the base of the right ventricle. Note the marked dissimilarity in the apparent shape of the heart in the two different projections.

This has been arranged in the following way. A part of the exposure voltage is conducted via a transformer, past the amplifier, direct to one of the galvanometers of the electrocardiograph, in our case to the fourth lead. On exposure, a characteristic mark is made, which also enables the length of the exposure to be measured exactly.

In recording the electrocardiogram, special precautions are necessary with regard to the 50 cycle alternating current, which may easily produce disturbances in the curve, as may also the high voltage, pulsating direct current. Ordinary electrodes with screened cables are used. The examination table, the patient and the assistants holding the child must be grounded.

On the same paper as the electrocardiogram there is also recorded a signal from the syringe, given at the very moment when the injection is completed and thereby the external pressure on the blood circulation system is removed.[8]

Over a resistor at the grounded midpoint of the high tension transformer, a voltage proportional to the current through the tubes is taken and visualized on the screen of a cathode-ray tube. The image on the screen is persistent long enough to enable a control of every exposure to be made and the amplitude to be read, which, when compared with a scale calibrated in recti-

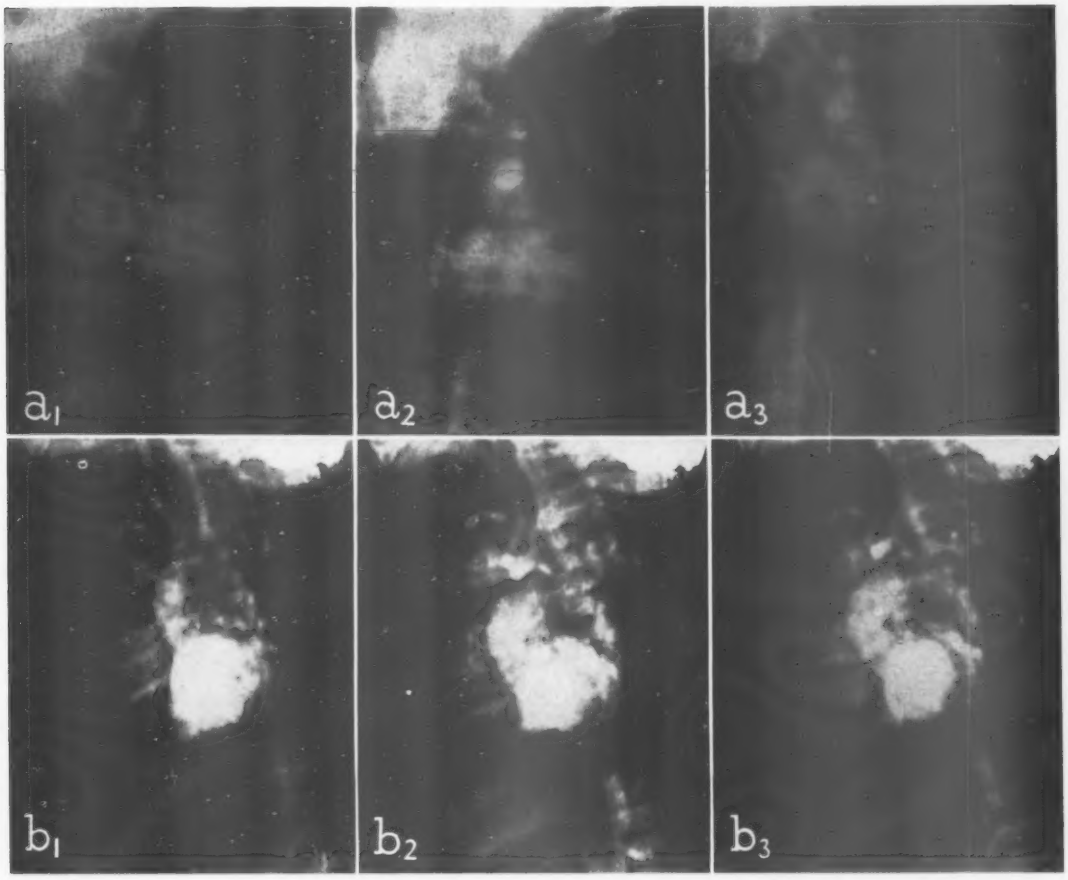

Fig. 6. Visualization of the left heart, times of exposure as in Figure 5. A series of angiocardiograms showing the action of the left heart. One can follow the concentric dilatation of the left auricle during which it maintains its round form (a_1–a_3). The contraction of the latter takes place about a central axis and the distribution of the residual blood differs therefore from that seen in corresponding condition of the right ventricle. Even changes in shape and caliber of the aorta during the heart cycle can easily be followed by the broadening and diminution of the convexity of the arch during systole (b_1–b_3).

fied mean values, gives the sum of the currents through the two tubes. One of the tubes can easily be disconnected, and by this means the milliamperage in each of the tubes can be checked.

Control by screening of the position of the patient in relation to the exposure fields can be provided for by using an additional and mobile table with the same plane-angle configuration as the cassette changer or "base-table." This mobile table, on which the patient is placed, can be shifted in the direction of the length of the base-table between two positions, one immediately above the base-table, touching it, and the other quite outside the base-table. The positioning of the patient can be made with the mobile table in the latter position by means of fluorescent screens in its surface, which correspond to the exposure fields in the base-table. When the adjustment has been made by screening with the roentgen tubes, moved in corresponding position, these fluorescent screens are removed to allow the free roentgen-ray passage, and the mobile table, with the patient on it, as well as the roentgen tubes is moved into the exact position over the exposure fields in the base-table.—The apparatus may be considered as being constructed for two vertical exposure fields, just as in the above described apparatus arranged for one horizontal and one vertical exposure field.

PROCEDURE AND RADIATION DOSAGE

The size of the film used in our apparatus today is fixed at 18 by 24 cm., and the focal

film distance employed is 90–120 cm. Kilovoltages varying from 65 to 80 kv. (peak) are chosen, depending on the tissue thickness of the patient. Long cones are used and they are adapted to cover the film field exactly. Exposure times are 0.02 second for infants and children, and 0.04 second for older patients.

The patient can be placed in position for simultaneous frontal and lateral projections. We usually prefer to use both oblique projections simultaneously, so as to obtain films of the different cavities of the heart projected to the greatest possible degree free from one another. In Figures 5 and 6 it may be seen how the first right oblique position gives a very fine projection of the auricle, free from the ventricle both in the right and left half of the heart.

The radiation dosage naturally depends on the kilovoltage used, the tube current, the film-focus distance and the exposure time. In the case of children aged from six to eight years, the actual exposure data, namely 75 kv. (peak), 450 ma., 90 cm. film-focus distance and 0.02 sec. exposure time, show, by actual measurement with an ionization chamber, that the patient receives 9 roentgens on the skin (average dosage over both fields) for 50 exposures in each plane, i.e. when 100 films are taken in four seconds. This dosage of 9 roentgens may lie far below the amount of exposure which is considered to entail a risk of radiation damage.[5,9,13,14]

CONCLUSIONS

Roentgenology has created normal standards of the size, shape and position of the heart in the living—a necessary prerequisite in the field of clinical medicine. These standard values, whether obtained from roentgenograms or orthodiagrams, however, represent static abstractions from a physiological process. Roentgenology has previously been one of static concepts—it has become roentgen anatomy.

The heart has, however, no fixed size or shape, no fixed position—as a result of physiological alterations, the heart is subjected to continuous changes in its absolute and relative dimensions. Any description of it must at least be qualified by a statement of the conditions existing at the time of the observation. Even then the knowledge so obtained is only fragmentary.

With the introduction of angiocardiography, the risks of erroneous judgment in diagnosis of heart conditions by merely static methods are again brought to the fore. Angiocardiograms, taken in a haphazard manner and without regard to the phase of the heart, and at the customary intervals of from 0.5 to 1 second, sometimes give rise to erroneous conclusions; e.g. the size of the cavities or the proportions between the different cavities, both depending upon the phase in which they are caught.

The aim of angiocardiography must therefore be to obtain so far as possible a continuous objective recording of the working of the heart. It is in the first place by these means that we shall gain a physiological and pathophysiological knowledge of the dynamics of the heart, which is necessary for a thorough clinical concept of cardiological cases. It is only in this way that the working of the heart and its disturbances can be fully exploited in diagnosis. A physiological living unity is presented for judgment instead of merely the fragments, which go by the name of size, morphology, position, etc.

From our attempts at working out an angiocardiographic technique which would be satisfactory from a physiological standpoint, certain points have been considered worthy of note. An appreciation of the size of the different chambers of the heart and their alterations can, since the heart is a three-dimensional body, be built up only by synchronous roentgenography in two planes. The sequence of exposures, which must be sufficiently rapid to follow the dynamics of the heart through the different heart phases, must attain 10–12 films per second in order to be applicable

even to infants with their rapid heart rate. The exposure time must not exceed 0.02 second for infants, and 0.04 second for older children and adults. Direct roentgenography is to be preferred to photofluorography both because of the smaller radiation dosage for the patient and the higher quality of the roentgenograms. Our apparatus for serial roentgenography, described in this paper, fulfills these requirements. The films are made synchronously in two planes, with an exposure sequence of 0.08 second between each pair of films, i.e. 12.5 films per second. The films are taken by direct roentgenography, and the exposure time is as low as 0.02 second. Finally, an objective judgment of the number of exposures per heart cycle, and of the relation of each separate exposure to the electrocardiographically recorded heart phase is rendered possible by a synchronous electrocardiographic recording showing the exposures on the electrocardiogram.

SUMMARY

After a discussion of the importance of being able to record roentgenographically the dynamic processes of the internal organs, the special requirements which arise from the angiocardiographic study of the dynamics of the heart are set forth. An account is then given of an apparatus which, by the development of direct serial roentgenography, synchronous in two planes, giving films at 0.08 second intervals, fulfills these requirements of angiocardiography even in the case of the rapid heart rate attained in infants.

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RETROGRADE OR COUNTER-CURRENT AORTOGRAPHY

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LATELY, we have seen various articles published in North American periodicals dealing with retrograde aortography and its application in the diagnosis of various different cardiovascular anomalies. It has been our impression that the method is simple, innocuous and highly valuable.

In the text and in the discussion of such articles no mention is made of the names of Castellanos and Pereiras as the first in the world to create, perform and even name the method which is today accepted by all investigators.

The facts mentioned above, and our desire to clear up certain points which are not quite well established in the articles to which we make reference, have induced us to undertake the publication of this article.

During 1936 and 1937 we performed numerous aortographic and angiocardiographic examinations by the injection of radiopaque substances through peripheral arteries of cadavers. By this method, the contrast substance goes from the periphery to the aorta and its branches, the left ventricle, the left auricle, the pulmonary veins, etc. And in cases of patent ductus arteriosus or interventricular communication the existence of such short-circuits or abnormal communications can be definitely established. Our publication on "Post-mortem Angiocardiography," in 1937, relates the technique of the method and also cites a number of the cases in which the method was applied, with the correct diagnosis of the existent anatomical defects[1,2,3,4,5,6,8,14,15] (Fig. 1).

In 1937, on account of an error (error committed later on by the British group of the Nuffield Institute of Oxford), we discovered it was possible to do retrograde aortography in the living subject and demonstrated its harmlessness, even in patients with serious cardiopathies. The radiopaque substance was injected, counter-current-wise, through the right femoral artery, and the roentgenogram taken in lateral position shows the abdominal aorta, part of the thoracic aorta and its branches.

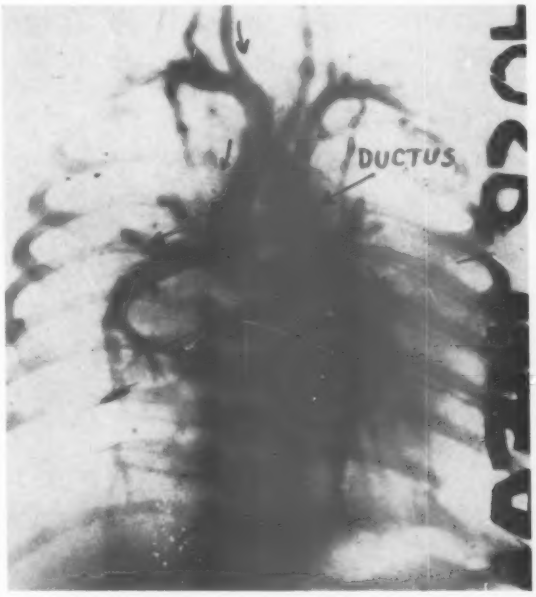

FIG. 1. Retrograde aortography in a cadaver. Diagnosis of persistence of arteriovenous duct. Through the ductus the radiopaque substance passes from the aorta to the pulmonary artery and its branches This illustration was published in *Arch. estud. clín. Habana*, 1937, p. 578.[1]

This roentgenogram was taken on December, 1937, but it was not published until two years later in the *Revista de la Sociedad cubana de cardiologia* (July, 1939–April, 1940, page 18) (see Fig. 2).

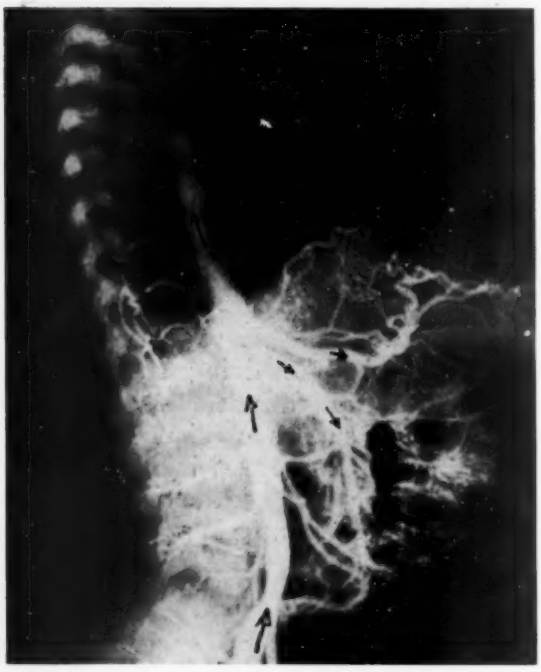

Fig. 2. Retrograde abdominal aortography in a newborn. This figure was published in *Rev. cubana de cardiol.*, 1939–1940, p. 189.[3a]

This method was also used for the performance of peripheral arteriographies in 1937. The report of the cases examined by the method were published by one of us (R. P.) in 1938[2] (Fig. 3).

In 1938 we worked with cadavers of children with patent ductus arteriosus as well as with cadavers of newborn babies

Fig. 3. Retrograde aortography. Complete visualization of the subclavian artery after injection through the axillary artery. Published in *Bol. Soc. cubana de pediat.*, 1938, p. 377.[2]

with the ductus arteriosus still permeable, or partially so. As a result of our experience, we came to the development of a technique for the diagnosis of persistence of the ductus arteriosus in the living child. The method was applied to many cases of congenital cardiopathies, some of them with patency of the ductus arteriosus.[1,5,6,14,15]

In 1938 at the Pediatric Assembly of Santa Clara, Cuba, held under the auspices of the Cuban Pediatric Society, a motion picture was projected, in which the technique and the results obtained were shown. The original film is still in our possession.[3]

In the above mentioned issue of *Revista de la Sociedad cubana de cardiologia* July, 1939–April, 1940, we published an article in English, with the explicit intention of demonstrating our method to Anglo-Saxon investigators: i.e., to let them know that the radiopacification of peripheral arteries of the extremities and of the aorta in living subjects was possible through the injection of a contrast medium, rapidly and against the direction of the blood flow.[3a,8]

Nothing could be more conclusive than a quotation from what we said on page 204 of that issue: ". . . We apply the term retrograde or counter-current aortography to the roentgenographic visualization of the aorta by means of injecting a contrast medium into a peripheral artery, contrary to the direction of blood flow in the artery. The possibility of visualizing radiographically the large arterial stems by injecting small peripheral vessels, opens a new path to vascular radiology . . . "

In October, 1940, Dr. Pedro L. Fariñas, of Havana, Cuba, presented in Mexico a modification of our aortographic method, consisting in the opening of the femoral artery and the introduction of a radiopaque catheter through this opening, so that the catheter can be placed at different levels, even in the thoracic region. Then a contrast substance is forcibly injected, and in this way a radiopacification of the aorta is obtained. In this modification, the contrast medium was injected from the tip of the

catheter directed toward the periphery[9] (Fig. 4).

In 1941 many articles were published in Cuba, reporting results obtained by the application of this method.

In 1942 we, with Cazañas,[8] published an article in English on the diagnosis of coarctation of the aorta by means of retrograde aortography. We related the clinical history of the patient and the results of aortograms performed through the right and left humeral arteries separately, demonstrating in the infant studied the existence of a coarctation of the aorta. Afterwards both the angiocardiographic and

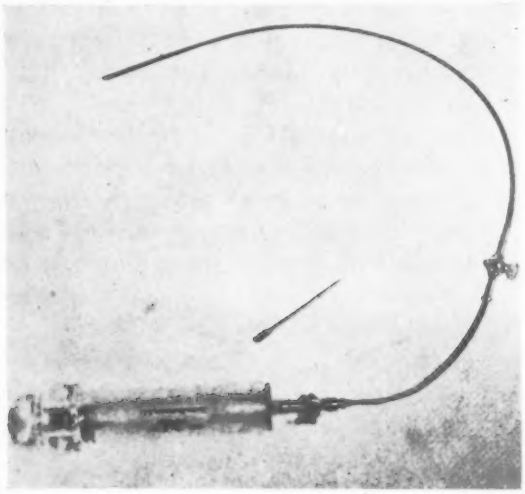

Fig. 4. Catheter used by Fariñas for his method of abdominal aortography, by catheterization of the artery. October, 1940.

aortographic diagnoses were proved at autopsy (Fig. 5).

In 1945 Barclay, Franklin and Prichard[12] of the Nuffield Institute of Oxford, by mistake performed a retrograde aortography in a recently born lamb fetus. The radiopaque substance entered a wide open ductus arteriosus, making the branches of the pulmonary artery stand out intensely (Fig. 6).

In 1946 Fariñas dropped his method of aortography by previous catheterization. He adopted definitely our retrograde or counter-current method (the method of Castellanos and Pereiras). Working almost

Fig. 5. Retrograde aortography in an infant with coarctation of the aorta. Roentgenogram published in 1942. Diagnosis confirmed at autopsy, months later. See visualized artery at the right instead of at the left. Anomaly diagnosed by this method.

exclusively with adults and senile subjects, he uses an original apparatus for the automatic high pressure injection of the contrast solution.[9,10,11]

In 1946, we, using our retrograde method,

Fig. 6. Retrograde abdominal aortography published in 1945 by Barclay, Franklin and Prichard, and performed in a lamb.

FIG. 7. Normal retrograde thoracic aortography. Personal case.

discovered an indirect roentgenological sign, pathognomonic of coarctation of the aorta.

In this historical review, we have not mentioned aortography by direct puncture because it is a completely different technique. Direct aortography was first described by Reynaldo dos Santos, of Portugal, who introduced a needle into the abdominal aorta. The method still continues with slight changes such as the nature of the injected radiopaque substance, roentgenographic techniques, etc. He is then in effect the originator of the method, although some subsequent articles do not mention the great Portuguese investigator; (e.g., the paper of O. A. Nelson, of Seattle, Wash.). In 1931 the first book of the great Portuguese author was published.

The method of direct thoracic aortography was originated by Jorge Meneses Hoyos and Carlos Gomez del Campo, of Mexico. They introduce a needle through the second left intercostal space into the aortic arch.

The above-mentioned methods are, as we have said, different in technique, and that is why we have limited ourselves to the historical considerations of the retrograde method, which is of more importance and interest to Anglo-Saxon authors.

The direct abdominal aortographic technique of dos Santos is used by various investigators for the diagnosis of abdominal aortopathies, aorto-iliac thrombosis and other abdominal conditions.

The technique of the Mexican authors, as far as we know, is seldom used by others than its originators.

The amazing progress of cardiovascular surgery in the United States and Sweden has given great importance to retrograde aortography, even though we initiated the method many years ago and have been using it since 1937.[1,2,3,3a,4,5,8,14]

We usually perform the injection through the axillary or the humeral artery. If the child is small, a few months old, we use the artery of either side, both in normal cases and in cases with cardiovascular anomalies.

FIG. 8. Retrograde superior or thoracic aortography. Coarctation of aorta. Personal observation.

So reaching the aorta and making it radiopaque are easy maneuvers. As an example, see Figure 10 of a child just a few days old. If the child is older, the left side is the one of choice for anatomical reasons which were pointed out in our above-mentioned original articles. We are satisfied with the roentgenograms obtained by this method[5,6,8] (see Fig. 5 and 9).

Lately, in 1948, Crafoord has done aortography by introducing a catheter into the radial, humeral or axillary arteries. He places the tip of the catheter within the aortic arch and then he injects the radiopaque medium, obtaining by this method radiopacification of the thoracic aorta and its large branches.

Freeman of Los Angeles, California, and Scott, Burford and Carson, of St. Louis, Missouri, prefer injection through one of the carotids, dissecting the vessel before the injection.

This technique of dissection of the vessel and then the injection was studied by us in 1937 in the cadaver for the performance of postmortem and angiocardiography in cases where permission for necropsy was denied by relatives. Our article of 1937 refers to Figure 1, which we reproduce.

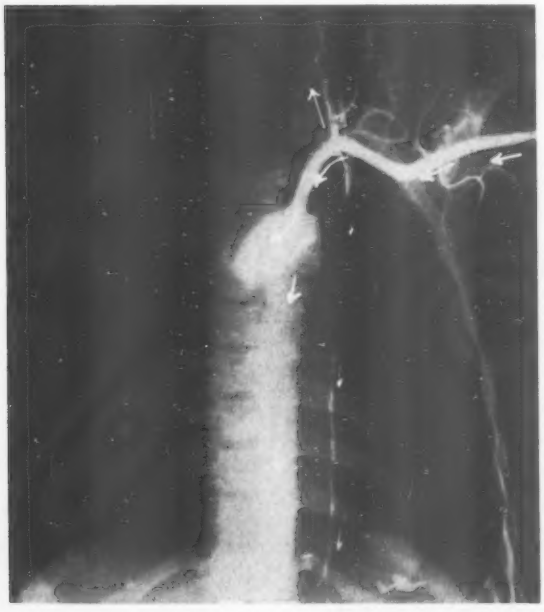

Fig. 9.. Normal superior aortogram. Published by Castellanos, Pereiras and Garcia, 1939–1940.

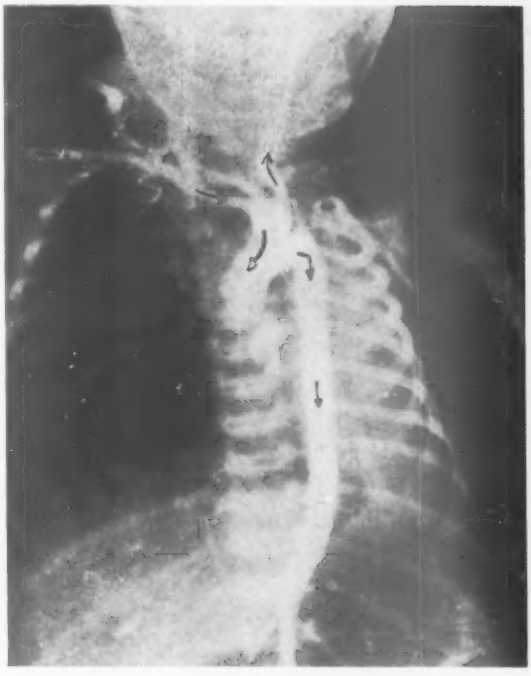

Fig. 10. Superior retrograde aortogram in a case of agenesis of the left lung. Published in 1939–1940.

Lately we have done superior retrograde aortography through the carotid artery, with good results, as can be seen in Figures 7 and 8. The first, a normal case, was in a child; the second, a typical coarctation of the aorta, in an adult.

Time has proved us to be right, when in 1939–1940 we wrote in English, in the above-mentioned article on page 204 of *Revista de la Sociedad cubana de cardiologia* the following:[3a]

" . . . Retrograde aortography may be practised in some cases instead of the Castellanos and Pereiras method of angio-cardiography; or complementing it, in certain cases of congenital heart disease. . . . "

In the paper which we presented recently at Los Angeles, California, we have divided aortographies into two groups:[6] (1) direct aortography; (2) retrograde or counter-current aortography.

Direct aortography is the method in which a needle is introduced directly into the thoracic or abdominal aorta, and the

Fig. 11. Abdominal or inferior retrograde aortogram. (Made on January 14, 1941, unpublished.) Normal case.

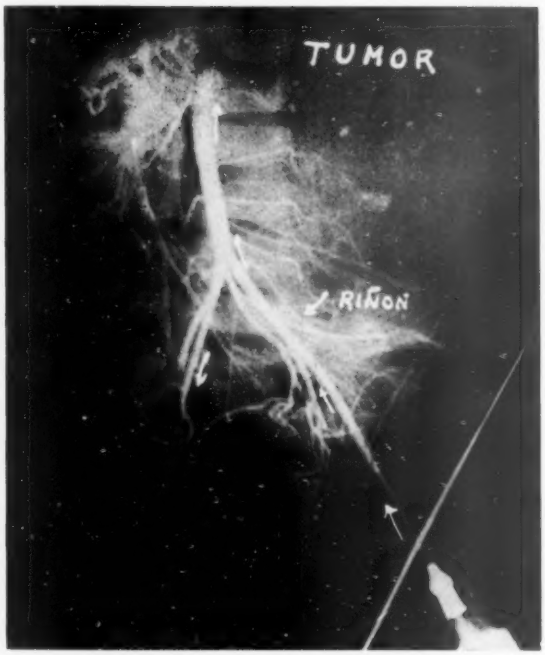

Fig. 12. Inferior aortogram. (Made on January 14, 1941, unpublished.) Wilms' tumor of the left side.

radiopaque substance is injected through this needle.

Retrograde aortography is the method in which the injection is done through a collateral or terminal branch of the aorta and the radiopaque substance is injected forcibly against the normal blood flow, i.e., centripetally.

We have subdivided retrograde aortography into (1) superior or thoracic and (2) inferior or abdominal.

We decided upon this classification on account of the numerous techniques already used for the performance of aortography, which demonstrate the great interest which our method of radiopacification of the aorta and its branches has produced throughout the world.

CONCLUSIONS

1. Retrograde aortography in living subjects or in cadavers, with normal or anomalous cardiovascular systems, was first performed by us in Cuba in 1937, and its practice has been continued since.

2. We have reviewed the papers published by us, demonstrating that we were already using it routinely before other workers began to employ the method.

3. We were the first to call the method "retrograde or counter-current aortography."

4. The method has become an established procedure and has become universally accepted on account of its usefulness and its harmlessness, although numerous variations of the method have been devised, depending on the research pursued by the investigator when he wishes a visualization of the aorta and its branches.

5. The retrograde aortographic method is a substitution for or complements angiocardiography, depending on the nature of the case.

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BIOLOGICAL EVALUATION OF 20 MILLION VOLT ROENTGEN RAYS*†

IV. EFFICIENCY AND DOSAGE RANGE

By HENRY QUASTLER *and* ELISABETH F. LANZL

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IN LAYING the groundwork for clinical and biological use of high energy roentgen rays, one must determine the biological efficiency of these rays. The efficiency, η, of any type of radiation is defined with reference to an arbitrary standard type. If $D(Y, s, u)$ is the amount of standard radiation and $D(Y, t, u)$, the amount of test radiation which gives the same response, Y, the doses being measured in some unit, u, then the efficiency is

$$\eta(t@s||Y, u) \equiv D(Y, s, u) \div D(Y, t, u).$$

η, as indicated, is a function of the two kinds of radiation, t and s, compared, of the particular response Y used in the determination, and of the unit u in which the quantities of radiation are measured.*

It has frequently been assumed that the "biological efficiency" of a type of radiation is the same for all biological responses. If this were true, an evaluation of doses in terms of "S.U.D." or "r.e.m." or any other unit based on some one biological response would be universally applicable. Experimental evidence accumulated during recent years has clearly shown that there is no such generally valid unit. Therefore, knowledge of the biological efficiency of a given type of radiation in any one context is not a sufficient basis for predicting accurately its efficiency in another context.

A general appraisal of the biological efficiency of a given kind of radiation must be based on determinations of η for a wide range of conditions. It is necessary to study diversified reactions[1,8,9] and, where possible, different levels of a given reaction. The latter is the purpose of this investigation.

The factors influencing the efficiency of a type of radiation are by no means completely known. However, theories have been developed which appear rather closely applicable to certain cases. Different types of reactions give different behaviors of η. One may consider the following examples.

(1) The sensitivity of the physical dosage measuring device may depend on the type of radiation used. A thimble chamber whose sensitivity depends on wavelength is an example. In such a case, a constant factor is introduced into any biological evaluation.

(2) The biological effect may be based on a simple mechanism which is the same for all types of radiation. This appears to be the case in small viruses. There is evidence that it is the occurrence of at least one ionization anywhere within a large fraction of the volume of a virus which causes its inactivation. D. E. Lea[7] has expressed the efficiency of any radiation in a reaction of this type in terms of the "associated volume," which is a calculable constant for any given radiation and target. Here, η will vary with the reaction investigated (e.g. with the species of virus inactivated), but is independent of dose and thus of the degree of response. Therefore, if the efficiency of a type of radiation has been determined for a given amount of response, say, 50 per cent inactivation, the efficiency for any other amount of that response can be predicted. Furthermore,

* The symbol is a modification of the one used by H. L. Gray.

* From the Departments of Physics and of Physiology, University of Illinois, and the Carle Foundation, Urbana, Illinois.

† This investigation was supported in part by a research grant from the National Cancer Institute of the National Institute of Health, United States Public Health Service.

by the target theory, unknown inactivation doses for viruses of known size and shape can be estimated with fair approximation.

(3) The biological effects may depend on mechanisms which differ according to the type of radiation used. For instance, some biological entity might react, in all-or-none fashion, if a given number of ionizations occurs within a given target space. This might take place upon the passage of one ionizing particle, if the radiation produces densely ionized tracks; it might occur after a large number of particles have passed. Glocker[5] has pointed out that, in some cases, radiations of different qualities produce a 50 per cent effect with approximately equal doses, thus, equal efficiency; for smaller doses, the radiation with lower specific ionization is less efficient, and for large doses, more efficient than the radiation with higher specific ionization. Thus, η varies here not only with the reaction investigated, but even with the particular dose tested.

In the three hypothetical cases just discussed, we found "efficiencies" of very diverse properties. In the first case, η contains a constant factor; in the second, η varies with the test reaction, but not with the test dose; in the third, η is valid only for a given test reaction and a given pair of test doses.

In all three cases, η could be calculated if all relevant factors and mechanisms were completely known; but this is not the case in the practice of radiotherapy and radiobiology. Still, it is not necessary to make separate determinations of efficiency for each reaction and each dosage level. There is no case known where the efficiency changes suddenly on going either from one test reaction to a nearly related one, or from one dose to a neighboring one. Therefore, it is quite safe to estimate unknown efficiencies by interpolation between known test reactions and known dose levels; estimates by extrapolation are hazardous.

A test of the variability of η with intensity of response, then, demands the use of a wide dosage range. The number of biological test reactions which are useful over a wide dosage range is not large. One of these is the survival time of mice under daily total body irradiation, and this was selected for the test reported here.*

EXPERIMENTAL PROCEDURE

The test objects used were C-57 Black mice of both sexes, and with weights ranging from 17.0 to 34 grams, with a mean of 25.2 grams.† The mice were kept in wooden boxes, 5 to a box, and fed on a diet of Purina dog chow and water.

The main experiment was arranged in a symmetrical design with two factors: quality of radiation (betatron at 20 mev. vs. conventional machine at 200 kv.) and dose level (high vs. low dose in a ratio of 1:0.224). Such a design provides a very sensitive test for variation of efficiency with dose.[4]

Sixty mice were irradiated with equal daily doses to the whole body until death occurred. They were divided into two groups of 30 mice, one for irradiation with 20 million volt roentgen rays from the betatron, the other with the 200 kv. beam from a conventional machine. Each group was further divided into two equal subgroups for the two dosage levels used. The doses selected were 80 r and 360 r for 200 kv. and 106 "r"‡ and 476 "r" for the betatron, the doses being determined as readings of a 25 r Victoreen condenser chamber when placed in the same position as the experimental animals. These pairs of doses would be equivalent if the efficiency at these levels were the same as for single massive doses.[9]

The high dose was expected to cause death in about six days, the low dose in about three

* Acute radiation death after a single massive dose has been used earlier to obtain an estimate of η (20 million volt @ 200 kv.). However, this reaction is useful over a short range of doses only. The survival times observed in acute radiation death are bounded by two stable values of 3½ and about 11 days.[10] If the response Y is constant over a significant dosage range, then $D(Y)$ is not uniquely defined and the factor η has no meaning. Thus, only the survival times between 3½ and 11 days can be used for the determination of η. Moreover, because of the variability in survival times, only values between 4½ and 9 days can be used safely. Such a range, i.e., a ratio of 1:2, means a dose ratio of only 1:1.4, because the survival time here varies inversely with the square of the dose. Therefore, the massive-dose-test is not appropriate for the investigation of the variability of η.

† With divided doses, the body weight has no marked influence on survival time.

‡ An "r" is the reading obtained with a thick-walled Victoreen 25 r thimble chamber. It is not necessarily identical with the absolute roentgen

weeks. In order to minimize the influence of all factors which might change during the experiment, each of the two high dose subgroups was divided into three sets of 5 mice, the three sets being treated in successive weeks. Thus the total period of time for the high dose test was approximately identical to that with the low dose, where the two groups of 15 mice were irradiated from the beginning.

The four sets of mice were approximately matched as to litter provenience, age, sex, and weight. All mice were kept in the same room and irradiated daily at about the same time. All were subjected to transportation to both places of irradiation. (We realized too late that a more strict control could have been obtained by subjecting each mouse every day to a dummy treatment on the complementary machine, in addition to the planned irradiation.) Thus, the trauma of handling was almost, though not quite, alike. Controls in each group were subjected to dummy irradiations, and showed no sign of damage.

The two groups of mice (betatron and conventional machine) were matched closely, but not perfectly with regard to dose distribution. For irradiation with 200 kv. roentgen rays, the mice were placed in a rectangular cell in a block of presdwood, and irradiated from above (no filter except inherent filter plus one $\frac{1}{4}$ inch sheet of presdwood, target distance 52.5 cm, 51 r per minute). With this arrangment, the dose received is about six per cent higher on the dorsal than on the ventral surface of the mouse.[10] The presdwood phantom used for the betatron[9] (Fig. 1) has six cylindrical holes with axes lying approximately on one isodose surface. The dosage gradients in the betatron beam are rather steep. Since the holes are 1 inch in diameter, that portion of the mouse which is nearest the center of the beam receives a dose up to 30 per cent higher than the portion farthest away. The top hole in the phantom, which would give the highest dose to the ventral region, was always occupied by the monitor during the irradiation. The mice were assigned to the remaining five holes at random. Therefore, the expected cumulative depth dose distribution for the betatron mice was approximately the same as for the 200 kv. group. With the betatron, however, each mouse was subjected to some daily variation of dosage dis-

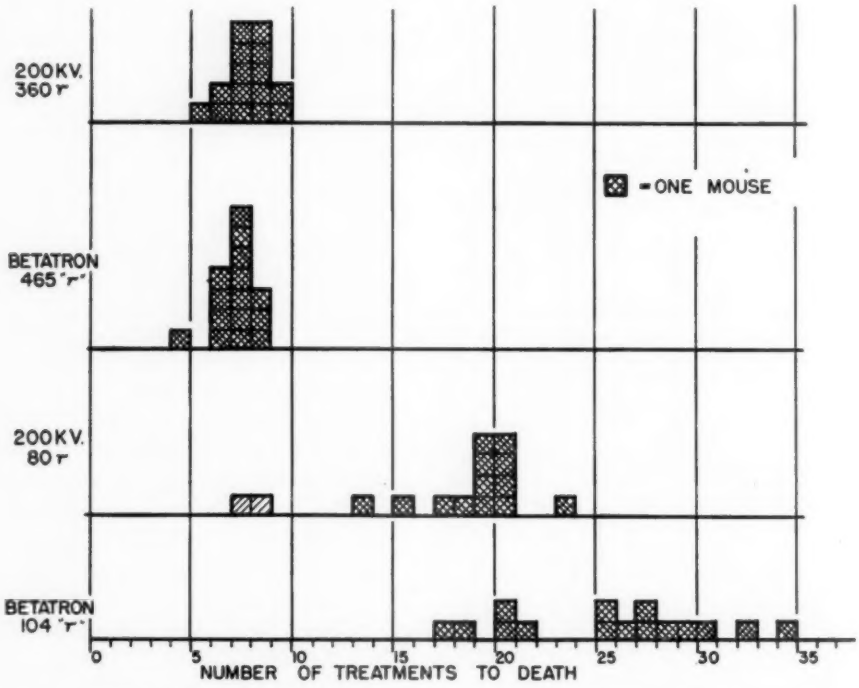

Fig. 1. Survival of mice under daily irradiation, at two dose levels, with two qualities of radiation (betatron at 20 million volts, conventional deep therapy machine at 200 kv.).

tribution, according to the hole occupied. This did not occur with the conventional machine.

A similar situation existed with regard to dosage rate and daily dose. The averages are nearly perfectly matched. However, daily variations were considerable on the betatron and negligible with the conventional machine. On the latter, a dosage rate of 51 r per minute was used throughout the experiment. On the betatron, dosage rates can ordinarily be fairly well reproduced from day to day. It happened that three successive tubes became defective while the experiment was in progress; each replacement gave a somewhat different output. Also, the output was affected by the fact that the machine was in almost constant operation for various experiments every day. For these reasons, it was impossible to maintain a constant dosage rate, except at a very low value. Therefore, the maximum available output was used each day. The mean rate was 58 r per minute; the extreme rates were 29 and 88 r per minute.

To achieve constancy of daily doses with the betatron, several dosimeter readings were taken before each irradiation to determine the dosage rate, and the exposure was timed accordingly. The monitor, a 250 r thimble chamber, was read at the end of each low dose run, and two additional times for the high dose. Daily doses varied from 84 r to 134 r in the low dosage group, and from 423 r to 518 r in the high dose group, with averages of 106 r and 476 r. These variations are due to fluctuations in output in the course of irradiation. Each day, the doses were planned to give the correct total dose. Thus, each group received finally within 1 per cent of the total dose intended.

The doses indicated above were those read in the monitor hole. An additional source of slight daily variations lies in small differences in dose between the five test holes. These differences did not remain constant because the phantom had to be realigned when the tubes were replaced, and this was not done perfectly. However, the average dosage rates for the five holes were the same as the rate in the monitor hole within 1 per cent.*

Several auxiliary experiments were performed, using the same techniques as in the main experiment.

* After one irradiation only, it was found that the beam had spontaneously changed its direction. This may have caused considerable error in one daily dose, but could not have introduced any serious error into the final result.

RESULTS

The results of the main test are shown in Figure 1. One sees that, in the high dose class, the betatron mice died somewhat faster than those treated on the conventional machine. In the low dose class, the betatron mice died more slowly. Yet the ratio of high and low dose is practically the same for both machines. This indicates that η (20 mev. @ 200 kv.) does change between the two classes tested if it can be shown that (1) the differences observed are beyond the range of chance fluctuation, and (2) there is a monotonic change of survival time with dose in the range investigated. The first proposition was verified by statistical evaluation, the second by auxiliary experiments.

A. *Statistical Evaluation of the Main Test.* All survival times were converted into logarithms (base 10), and the means and sums of squared deviations calculated. The results are entered in Table 1. The material was treated according to R. A. Fisher.[3,4] Statistical significance was estimated by the z-test for variability and by the t-test for deviation of a mean from an expected value.

(a) The variances for the six subgroups in the high dose group do not differ significantly from each other. Also, the average variances do not differ significantly between the two machines (z-test). Thus, the six variances can be pooled for the subsequent tests.

(b) The differences within the three subgroups of each high dose group are not significant (z-test). Thus, the three subgroups in each group can be pooled. The variance in the high dose group, estimated on the basis of the whole material, is 0.049.

(c) The difference between the two high dose groups (betatron vs. conventional machine) is of questionable significance (t-test). Chance fluctuations would produce a difference of this magnitude in about one out of four tests.

(d) In the low dose group, the first 2 mice to die were not pure radiation victims. One had a badly infected bite, the other a

purulent pneumonia in one lobe. These 2 mice were excluded in calculating the table and the statistics which follow. However, the same calculations were also performed with inclusion of these 2 mice, and the final result is about the same.

(e) The variances in the two low dose groups are compatible (z-test) and can be pooled.

(f) The difference between the two low dose groups (betatron vs. low energy) is significant (t-test). A difference of this magnitude would occur by chance only in one out of several hundred tests.

(g) The pooled variances of high and low dose groups are compatible (z-test). It is therefore legitimate to derive a statistics from all four sets together.

(h) If both the differences between betatron and 200 kv. groups were due to chance, then the "interaction quality x dose"[4] should vanish. This interaction is found by forming the two diagonal sums of log survival time, betatron—high dose plus 200 kv.—low dose, and betatron—low dose plus 200 kv.—high dose, and subtracting one from the other. The result is 0.16, and the standard error of this figure is about 0.01. Hence the difference from zero is eminently significant (t-test).

(i) The conclusions drawn are as follows: The difference in survival times between the two high dose groups is of questionable significance, i.e. the efficiency here must be close to that for acute death. The difference between the low dose groups is very probably significant. The efficiency at this level should then differ significantly from that for acute death. This means, as is also shown in (h), that the difference between the differences—and that is the main object of this investigation—is practically certain: the doses at the two levels do not give proportional effects. The interpretation of the differences must be made by means of auxiliary texts.

Table I

Logarithms of survival times

	Group	Betatron at 20 Million Volts		200 kv.	
		Mean	Variance	Mean	Variance
High dose	I	0.81	0.0011	0.87	0.0025
	II	0.75	0.0105	0.78	0.0066
	III	0.81	0.0039	0.81	0.0016
	Total	0.79 (6.2 days)	0.0051	0.82 (6.6 days)	0.0036
Low dose		1.38 (24.0 days)	0.0090	1.25 (17.8 days)	0.0031

B. *Auxiliary Tests.*

(j) For comparison with the lethal effect of divided doses, three massive dose tests were performed during the main experiment. The betatron doses given were 940, 1,080, and 1,254 "r," while the doses at 200 kv. were 720, 830, and 962 r. Thirty mice, 5 for each dose, were used. This experiment gave a value for η (20 mev. @ 200 kv.) of 0.78, which agrees closely with the earlier value[9] of 0.79 and with the η of 0.84 for the high daily dose (see (o)).

(k) One of the differences between the two groups of mice treated was the variation of daily doses on the betatron and their constancy with the conventional machine. The significance of this difference can be estimated in the light of data previously collected (1943–1944; unpublished). Three groups of 4 mice each were treated with

100, 141, and 200 r, respectively, of 200 kv. roentgen rays every other day. The resulting mean logarithmic survival times were 1.31, 1.30, and 1.06, as compared to 1.41, 1.29, and 1.08, obtained with daily doses of half the above amounts. Even though the daily variation in dose was much larger here, the differences in survival times are smaller than that found between the two low dose groups (1.38 and 1.25) in the present experiment. On this basis, one may exclude the variation in daily doses as the cause of the difference in response between mice treated with the betatron and with the conventional machine.

(l) The slope of the survival time-dose curve at the higher dose level was determined for 200 kv. by subjecting groups of 6 mice each to daily doses which were 99 r higher and lower, respectively, than the high dose (360 r) used. This test was performed concomitantly with the last high dose run, and was not paralleled on the betatron. The average survival times were 5.8 days at 4.59 r, and 7.5 days at 261 r daily. The means of the logarithmic survival times were 0.75 and 0.87, with variances of 0.0051 and 0.0012, respectively. By linear interpolation, using these two values and also 0.82 at 360 r, one finds that the mean logarithmic survival time of 0.79 for the higher betatron dose corresponds to an equivalent dose at 200 kv. of 402 r. The dose measured with the thimble chamber was 476 r.

As stated in the introduction, efficiency is defined as the ratio of a dose which produces a given response under standard conditions to the dose which produces the same response under test conditions. Thus, η (20 mev @ 20 kv.) is estimated at $402 \div 476 = 0.85$ for a comparison based on the biological response of death in about one week under daily irradiation, with dose units as indicated by the Victoreen condenser chamber.

(m) The slope of the survival time-dose curve at the lower dose level (80 r daily) was not determined at the time of the main experiment, but can be evaluated on the basis of earlier experiments, performed at the same time as the test mentioned in (h). At a dose rate of 33.6 r per minute, 6 mice treated with 50 r daily had a mean logarithmic survival time of 1.42; 2 mice at 70.5 r, 1.29; and 6 mice at 100 r, 1.08. For 80 r, linear interpolation gives a log survival time of 1.215, instead of 1.25 as found in the main experiment. If one adjusts the survival time of the low dose betatron group on this basis, by subtracting the difference, 0.035, from 1.38, one obtains an equivalent dose of 60.5 r, and an η of $60.5 \div 106 = 0.57$ for death in about three weeks under daily irradiation.

(n) The slopes of the survival time-dose curve differ considerably at the two dose levels. In the neighborhood of 360 r, the log survival time decreases by about 0.0006 per r; around 80 r, by 0.007 per r. In a test like those used in (h) and (m), the slope around 150 r was found to be about 0.002 per r. Therefore, linear interpolation is valid only for small ranges. However, the whole range of dose-survival time relations, for 200 kv. rays with divided doses can be well fitted by the formula

$$r(t-3.5) = 1066,$$

where t is the time in days* between first treatment and death, and r is the daily dose. (Doses used in 1943–1944 were adjusted on the basis that 75 r then gave the same effect as 80 r at the time of the main test—see (m).) The survival time is thus a monotonic function of the daily dose

(o) Interpolation by means of the formula stated above should give equivalent doses which are more reliable than those obtained by linear interpolation. The formula gives 398 r for the high and 52 r for the low dose, as compared to the previous values of 402 and 60.5 r.

With these better values, the efficiencies for the two dose levels are as follows: for death of mice in about one week, η (20

* Exactly: The antilogarithm of the mean logarithmic survival time.

mev. @ 200 kv.) = 398 ÷ 476 = 0.84; for death in about three weeks, η (20 mev. @ 200 kv.) = 52 ÷ 106 = 0.49.

DISCUSSION

In each of the three preceding parts of this series,[1,8,9] the determination of η (referred to as efficiency, effectiveness, or conversion factor) was based on a single reaction, and on a small range of doses. The three values found (0.78, 0.70, 0.75) agree quite well with each other. Their difference from 1 is statistically significant. It was pointed out that this difference could be due to a deviation of the physical dosimeter as well as of the biological response from the dose readings obtained at 200 kv. If the three values of η had shown significant differences, the presence of a biological factor would have been confirmed.

In the present experiment, the contribution to η of a biological factor was proved. This was made possible by designing the experiment in such a way that a result independent of the physical unit of dose employed could be obtained, namely by conducting, in effect, two independent experiments, distinguished only by dose level and response, but identical in every aspect pertaining to physical dosimetry. In this way, a difference in η between the two experiments must be due to biological effects. The same factor, if any, due to the dosimeter is contained in each of the two η's, so that their ratio must be independent of physical dosimetry. This ratio is η (20 mev. @ 200 kv. $\|$ 3-week death, 1-week death) = 0.49 ÷ 0.84 = 0.58.

Although this value is subject to statistical error, its difference from 1 is definitely significant. Furthermore, since survival time was found to be a monotonic function of dose, no other (higher) value for the equivalent dose, which would give a larger η, can exist at either dose level.

Is this differential effect for 20 million volt and 200 kv. roentgen rays due to the difference in quality of radiation, and to nothing else? As pointed out earlier, other differences between the two sets of mice lie in the regularity of daily doses, dosage rates, and dose distribution, as well as in the trauma in handling during treatment. Complementary dummy irradiations were not carried out. However, since the control animals, which did receive dummy treatments, suffered no apparent damage, one can conjecture that the differences in handling were not significant. Moreover, the betatron mice, which were subjected to the more severe trauma, lived longer than the 200 kv. mice in the low dose group, where the trauma occurred most frequently.

The effect of variation of daily dose can be dismissed on the basis of the experimental comparison of daily irradiation with treatment on alternate days with the double dose. This comparison, made in the neighborhood of the lower dose level, failed to demonstrate a significant difference in efficiency.

No direct check on the influence of dose rate was made. However, it is known that, in general, variations much greater than those which occurred in the present test are needed to influence the efficiency. Also, no direct test on the effect of a variable dose distribution was performed. We know that irradiating the whole body has a greater lethal effect than does irradiating half the body with twice the dose. Thus, a variable dose distribution might lessen the efficiency, but it is not likely that a small variation would cause a differential effect which is much greater than that of sparing the whole body on alternate days.*

We may conclude, then, that the change in efficiency observed with increased fractionation of doses is due to the difference in quality between the two types of radiation, and probably not to the small concomitant differences in experimental procedure.

It is generally assumed that differences in efficiency between radiations are correlated with differences in specific ionization. The specific ionization in a high energy roentgen-ray beam is approximately equal

* See Addendum.

to that produced by the γ rays of radium. For both, it is about one-tenth of that in a beam of unfiltered 200 kv. roentgen rays. On the other hand, the specific ionization in a neutron beam is, roughly, ten times as high. For reactions where γ rays are more efficient than conventional roentgen rays, neutrons are less efficient; the reverse is also true. We have found that, for the lethal effect in mice, the efficiency of high energy roentgen rays, compared to the standard of roentgen rays of conventional energy, is reduced by high fractionation of doses. Accordingly, one would expect neutrons to become more efficient with higher fractionation. This appears to be the case.

Henshaw, Riley and Stapleton[6] determined η ($n@\gamma$) for two reactions in mice, namely, incidence of acute death after one massive dose, and 23 per cent reduction of lifetime by daily doses. The physical units used were the n (reading of a 100 r thimble) for neutrons, and the r for γ rays. They found

$\eta(n@\gamma \| Y = \text{L.D. } 50;\ u = n,\ r) = 12$

$\eta(n@\gamma \| Y = 23$ per cent reduction of life by daily doses, $u = n,\ r) = 35.$

If the first of these values is regarded as a calibration of n in r.e.m. (r.e.m. = r for death by a single roentgen-ray dose), the physical dose unit is eliminated in the expression

$\eta(n@\gamma \| Y = 23$ per cent shortening of life by daily doses, $u = \text{r.e.m.}) = 2.9.$

Thus, with neutrons, the fractionation of doses leads to a greater efficiency.

Evans,[2] in a similar study comparing neutrons and roentgen rays, found that

$\eta(n@x \| Y = \text{L.D. } 50;\ u = N,\ r) = 8.1$

$\eta(n@x \| Y =$ death in about 3 weeks by daily doses; $u = N,\ r) = 8$

$\eta(n@x \| Y = 40$ per cent reduction of life by daily doses; $u = N,\ r) = 18.$

Eliminating the physical dose units as before by substituting the r.e.m., one obtains

$\eta(n@x \| Y =$ death in about 3 weeks by daily doses, $u = \text{r.e.m.}) = 1$

$\eta(n@x \| Y = 40$ per cent reduction of life by daily doses, $u = \text{r.e.m.}) = 2.2.$

Therefore, in a "subacute" test (which corresponds to our lower dose level), the relative efficiency of neutrons was found to remain unchanged. With still higher fractionation, however, a very definite change occurs.

It is not unlikely that the efficiency of radiation administered in divided doses is influenced by mechanisms of recovery. If this is the case, it seems that, for equal acute effects, the interference with recovery is greatest with neutrons, less with roentgen rays of conventional energy, and least with high energy roentgen rays.

SUMMARY

1. The efficiency of 20 million volt roentgen rays produced by the betatron was compared with that of conventional roentgen rays at different dose levels.

2. The lethal effect of divided doses on mice was used as test reaction.

3. At a dosage level which causes death after about one week of daily treatments, high energy rays are about as efficient as in the massive dose test; at a dosage level which causes death after about three weeks of daily treatments, their efficiency is significantly lowered.

4. The lower relative efficiency of high energy roentgen rays at small doses is compared to the higher relative efficiency of neutrons under similar conditions.

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ADDENDUM

A basic difficulty in matching the effects of high and low energy rays is emphasized again in a paper by F. W. Spiers (Spiers, F. W. The influence of energy absorption and electron range on dosage in irradiated bone. *Brit. J. Radiol.*, 1949, *22*, 521–533). He found that, in a beam of conventional roentgen rays, the bone marrow will receive a dose considerably higher than other tissues (because of the surrounding bone). No such effect occurs in a beam of high energy rays. Thus, even if dosage distributions are perfectly matched for a water phantom of the size and shape of a mouse, the bone marrow will actually receive an excessive dose in the case of low energy radiation. This physical difference might affect the relation between bone marrow responses and other radiation effects, even if there is no difference in the cellular mechanism of response.

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DEPARTMENT OF TECHNIQUE

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A SIMPLIFIED POSITION FOR DEMONSTRATING THE CERVICAL INTERVERTEBRAL FORAMINA*

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WITH greater emphasis being placed on the status of the cervical intervertebral foramina in the differential diagnosis of radicular pain in the neck, shoulder and arm region, a simpler and more rapid method of examination of this region than the conventional oblique projections is desirable. We have found that by using the standard technique for a lateral projection of the skull with the principal rays centered through the mid-cervical region, all of the cervical intervertebral foramina, from the second to the seventh, are well visualized. The advantage of this method is the relative ease with which this projection is obtained.

Kovacs[5] states that the use of lateral skull exposures with the patient in the "abdominal position" is commonly used for demonstration of the intervertebral foramina of the neck; however, review of the American literature and textbooks reveal no reference to this method.[1–4,6–11] Kovacs uses this procedure in addition to putting the film and the focusing screen in a paper sheath so that they can be placed against the patient's neck and thus bring the intervertebral foramina within a distance of 4–5 cm. from the film. We have found that the distortion produced by using the standard metal cassette with intensifying screens in the tray of the Potter-Bucky diaphragm was not a disturbing factor.

Procedure. The patient lies on his abdo-

Fig. 1. Simplified position for demonstrating the intervertebral foramina of the cervical vertebrae. See text for details.

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Fig. 2. Normal intervertebral foramina of the cervical spine using technique described in text.

Fig. 3. Intervertebral foramina of the cervical spine of patient complaining of severe radicular pain. Note encroachment of the upper cervical intervertebral foramina. Patient complained of pain in neck and both shoulders for several years. The calcified thyroid gland was an incidental finding.

men (prone) on the table with his head turned with the side to be examined toward the cassette. The head is placed in a perfect lateral position by propping up the chin and lower cheek with a small block, sand bag, or with the patient's closed hand. The Potter-Bucky diaphragm is used and the central ray of the roentgen-ray beam is centered through the mid-cervical region (Fig. 1).

Figure 2 shows the cervical spine using the above technique. Note the clearly outlined normal intervertebral foramina. The technical factors involved in obtaining this roentgenogram were as follows: distance, 36 inches; kv. (peak), 48; ma-sec., 150; parspeed screens.

Figure 3 shows a cervical spine using the above technique. Note the narrowing and encroachment of the upper cervical intervertebral foramina. The patient is a sixty-four year old white male who had pain in the neck and both shoulders of several years' duration. On twisting his head to the left he felt pain which on one occasion lasted for three days.

SUMMARY

A relatively simple method for examination of the cervical intervertebral foramina is described.

We wish to thank Dr. Donald Peik and Mr. Leo C. Massopust for their work in reproducing the photograph and films respectively.

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Fifty-first Annual Meeting: Jefferson Hotel, St. Louis, Mo., September 26–29, 1950.

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Thirty-second Annual Meeting: Roosevelt Hotel, New York, N. Y., May 25–26, 1950.

EDITORIALS

DISPOSAL OF RADIOACTIVE WASTES IN A GENERAL HOSPITAL

THE increasing use of radioactive isotopes in medicine has created several new problems from the point of view of safety to the patient, the attending personnel, and the public. Some of these problems have to do with permissible doses from various sources, others with undesirable immediate and late effects, and still others with the handling of the numerous and mostly very complex radioisotopes. It is important that certain minimal protective measures be taken to meet any situation that might arise. During the past few years considerable attention has been focussed on the problem of disposal of wastes from general hospitals or research institutions using radioactive isotopes for diagnostic, therapeutic or experimental purposes.

Very recently, Scott[1] made a notable contribution toward the solution of this problem by studying the disposal of radioactive wastes at the Medical Center of the University of California in San Francisco. His study is based upon data obtained in conjunction with the therapeutic use of the most common radioisotopes, as of today.

Scott found that when an institution houses 50 patients receiving ordinary radioisotope therapy the activity of the daily waste output may be as high as 1 curie per day. He estimated that if 20 of these 50 patients are treated with a probable dose of 100 millicuries of I^{131}, another 20 with a probable dose of 20 millicuries of P^{32} and the remaining 10 with a probable dose of 100 millicuries of other fission products and radioactive rare earths, the average daily excretion per patient would amount to 50 millicuries for the radioiodine, 1 millicurie for the radiophosphorus and 1 millicurie for the other fission products and radioactive rare earths. In other words, the total daily excretion for all patients would be 1,000 millicuries for the radioiodine, 20 millicuries for the radiophosphorus and 10 millicuries for the other fission products and radioactive rare earths.

If such highly concentrated radioactive material is admitted in the hospital sewer a dangerous situation may arise. This is especially true if the draining pipes contain many traps and pumps permitting the accumulation and storage of the radioactive isotopes for prolonged periods.

Scott also made some very enlightening estimates to illustrate the hazard that may accrue both inside and outside the hospital from the disposal of large amounts of radioactive wastes via the sewage system. To obtain more accurate figures, he assumed that no accumulation due to faulty or inaptly constructed plumbing fixtures takes place. If the above mentioned excretion of 1 curie of activity were diluted in the total one-day sewage output of the University of California Medical Center it would yield a gamma radiation, corresponding to 3 mr. per day in liter quantities. A 5 cc. sample of such a solution would produce over 50 counts per second in a Geiger-Müller counter. The beta activity in the vicinity of the accessible ranges would have considerably higher values, a 5 cc. sample producing over 1,000 counts per second in a beta-sensitive counter.

The sewers of most hospitals or institutions are connected directly with the public sewage system which is usually pro-

[1] Scott, Kenneth G. Radioactive waste disposal. How will it affect man's economy? *Nucleonics*, January, 1950, *6*, 18–25.

vided at its terminal with a filtering or processing plant. Scott calculated that the considerably greater dilution of the raw sewage at the San Francisco plant still would show an activity corresponding to about 100 counts per minute in a 5 cc. sample. The gamma-ray activity of such a solution would amount to less than 0.1 mr. per day.

Another possible hazard lies in the fact that the filter cake which is collected from the raw sewage is used for economic purposes, chiefly as fertilizer. In this manner radioactive wastes may be disseminated, contaminating fields, public parks, water pools, etc. Scott estimated that contact with a fertilizer made from a filter cake separated from the above described raw sewage could lead to a skin exposure as high as 2 rep per day. This dose would fog a photographic film in a few hours.

It is probable that with further extension of the medical use of radioisotopes, in some localities more than 50 patients will be treated simultaneously in various hospitals. If all these hospitals use a disposal of the radioactive wastes via the public sewage system an aggregate activity may result which is considerably larger than that estimated by Scott.

The dangers of such procedure were realized from the earliest time that radioactive isotopes were made available for the use of general hospitals. The problem has been accentuated by the fact that some of the industrial research laboratories use a similar method, although individually on a much lower scale for the disposal of radioactive laboratory wastes or radioactive-contaminated material. The National Committee on Radiation Protection, therefore, in 1949 appointed a Subcommittee on Waste Disposal and Decontamination. Considering the remarkably successful work that has been done for the health protection of the workers in the large atomic energy installations, this subcommittee already has some extremely useful data at its disposal. It is authoritatively estimated, however, that owing to the large number of the isotopes involved and the very complex nature of their behavior, it will require one and a half years before the subcommittee will be ready with formal recommendations.

In the meantime, the Isotopes Division of the Atomic Energy Commission, has issued a circular[2] giving interim recommendations for the disposal of radioactive wastes. These recommendations refer only to I^{131} and P^{32} which are the most commonly used isotopes in medical diagnosis and therapy and to C^{14} which is used mostly in research for labeling organic compounds.

In regard to radioiodine the interim recommendations specify that the radioactive material or the radioactive wastes may be discharged into the public sewage system only under certain provisions. The first of these provisions postulates that the volume of water flowing from the hospital outlet into the public sewer must be sufficient to dilute the I^{131} to 0.5 microcurie per liter or, when 1 gram of potassium iodide is added to each millicurie of I^{131} at the time of disposal, to dilute it to 10 microcuries per liter. The second provision is that the maximum activity disposed of from any one institution shall not exceed 200 millicuries per week. For the radiophosphorus a dilution of 0.1 microcurie per liter is specified and in order to prevent marked reconcentration by any organism in the sewage it is recommended that each millicurie of P^{32} be diluted with 10 grams of phosphorus as phosphate at the time of the discharge. There are, of course, other recommendations applying to various situations or accidents in conjunction with the general handling of radioactive isotopes. In the January, 1950, issue of this Journal Quimby and Braestrup[3] have given some very excellent advice concerning the planning of the radioisotope program in a hospital.

[2] Interim recommendations for the disposal of radioactive wastes by non-AEC users. (Circular B-6 by the Isotopes Division, Atomic Energy Commission) *Nucleonics*, August, 1949, *5*, 22–27.

[3] Quimby, Edith H., and Braestrup, Carl B. Planning the radioisotope program in the hospital. Am. J. Roentgenol. & Rad. Therapy, January, 1950, *63*, 6–13.

The future possibilities of radiosiotope therapy are still to be determined. At the present time very few hospitals or institutions make use of such large doses of radioactive material as those indicated by Scott in his estimates. Likewise, the diagnostic tracer studies and experimental investigations are being conducted on a comparatively limited scale. The interim recommendations, therefore, are sufficient to meet the immediate requirements. It is definitely stated, however, in the circular of the Isotopes Division that these recommendations will be enlarged as the use of radioactive isotopes is expanded and that eventually they will be superseded by the recommendations of the Subcommittee on Waste Disposal and Decontamination of the National Committee on Radiation Protection. It is essential that general hospitals or institutions making use of radioisotopes strictly follow these recommendations.

EDWARD C. KOENIG
1877–1949

Dr. Edward C. Koenig died on December 19, 1949, in the Buffalo General Hospital where so much of his life had been spent in the practice of radiology. The cause of his death was coronary occlusion. His illness was short, he having attended the Cleveland meeting of the Radiological Society of North America just two weeks previously.

Edward C. Koenig

Edward Koenig was born in Tonawanda, New York, on May 13, 1877. He graduated from high school in that city, and then attended preparatory school at Ithaca. From there he went to Yale University. His medical studies were at the University of Buffalo, from which he obtained his M.D. degree in 1904.

Following graduation he served his internship at the Buffalo General Hospital, and then returned to his home town of Tonawanda to begin general practice. He took time off from general practice for a year of study in Berlin and Vienna. Again in 1913 he went to Berlin for graduate training in roentgenology. He returned to Buffalo in 1914 to assume the position of chief roentgenologist at the Buffalo General Hospital, which position he retained until his death.

During World War I, Dr. Koenig volunteered his services and was commissioned a captain in the Army Medical Corps. He was detailed to the Rockefeller Institute in New York City. On discharge from service he resumed his work at the Buffalo General Hospital.

In addition to his hospital appointment, Dr. Koenig was Assistant Professor in Roentgenology at the University of Buffalo. He was a member of the American Roentgen Ray Society; Radiological Society of North America; American Medical Association; New York Medical Society; Erie County Medical Society; Buffalo Academy of Medicine; Buffalo Radiological Society; a Fellow of the American College of Radiology and the American College of Physicians; and a diplomate of the American Board of Radiology. He was also a member of the Buffalo Club; Saturn Club; Tonawanda Lodge, Free and Accepted Masons; Tonawanda Lodge, Royal Arch Masons; Lake Erie Commandery, Knights Templar; Buffalo Consistory; Ismailia Temple of the Shrine.

Dr. Koenig is survived by his wife, Ruby H., who resides at the family home in Eden, New York, and a son, Edward C. Koenig, Jr., of Haines, Alaska.

Dr. Koenig was, above all, a doctor. To him, patient-physician relationship and understanding were paramount. He will be remembered for many years by thousands of grateful patients in the Buffalo area. He was extremely helpful and generous to younger men in the profession, to whom he was ever willing to extend a helping hand. Dr. Koenig's passing leaves a vacancy in the community and in the profession which will be difficult to fill.

Gordon J. Culver, M.D.

HENRY LAWLER WILDER
1876–1950

Dr. Henry Lawler Wilder, aged seventy-three, of Pampa, Texas, died of coronary disease on January 28, 1950.

Dr. Wilder was born in Graham, Texas, on August 11, 1876. He was graduated from the University of Texas School of Medicine at Galveston in 1899, and he celebrated his fiftieth year of medical practice on May 13, 1949.

Dr. Wilder practiced general medicine for thirty-three years and specialized in radiology in Pampa for eighteen years.

Besides being an ardent civic worker, Dr. Wilder was instrumental in organizing many medical societies, among them the Stephens-Shackelford County Medical Society, 1903–1904; Hood-Somervell County Society; Childress-Collingsworth-Donley-Hall County Society, 1918; Dallam-Hartley-Sherman-Moore County Society, 1930; and Gray-Wheeler County Society, 1931.

He was elected councilor of the Panhandle District of the Texas State Medical Association in 1928. He was president of the District Society from 1924 to 1926.

He served as president of most of the societies he helped organize and held other offices, both in district and state societies. He was elected secretary of the Top o' Texas County Medical Society in 1948 and held the office until the time of his death.

Dr. Wilder had been secretary-treasurer of Frisco Central Medical Society and of Hood-Sommervell County Medical Society and the State Association of Medical Secretaries.

Dr. Wilder was a member of the American Roentgen Ray Society and of the American College of Radiology. He was also a diplomate of the American Board of Radiology.

B. R. Young, M.D.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. Barton R. Young, Germantown Hospital, Philadelphia 44, Pa. Annual meeting: Jefferson Hotel, St. Louis, Mo., Sept. 26–29, 1950.

American Radium Society
Secretary, Dr. H. F. Hare, 605 Commonwealth Ave., Boston, Mass. Annual meeting: Roosevelt Hotel, New York, N. Y., May 25–26, 1950.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N.Y. Annual meeting: 1950, to be announced.

American College of Radiology
Executive Secretary, William C. Stronach, 20 N. Wacker Drive, Chicago 6. Annual meeting: 1950, to be announced.

Section on Radiology, American Medical Association
Secretary, Dr. Paul C. Hodges, 950 E. 59th St., Chicago, Ill. Annual Meeting: San Francisco, Calif., June 26–30, 1950.

Alabama Radiological Society
Secretary, Dr. W. W. Anderson, Tuscaloosa, Ala. Meets time and place Alabama State Medical Association.

Arizona Association of Pathologists and Radiologists
Secretary, Dr. R. Lee Foster, 507 Professional Bldg., Phoenix, Ariz. Two regular meetings a year. The annual meeting at time and place of State Medical Association and interim meeting six months later.

Arkansas Radiological Society
Secretary, Dr. Fred Hames, 511 National Bldg., Pine Bluff, Ark. Meets every three months and also at time and place of State Medical Association.

Atlanta Radiological Society
Secretary, D. W. W. Bryan, 490 Peachtree St., N.E., Atlanta, Ga. Meets monthly, except during three summer months, on second Friday evening.

Brooklyn Roentgen Ray Society
Secretary, Dr. J. J. Daversa, 345 75th St., Brooklyn, N. Y. Meets monthly fourth Tuesday, Oct. through April.

Buffalo Radiological Society
Secretary, Dr. Mario C. Gian, 610 Niagara St., Buffalo, N. Y. Meets second Monday evening each month, October to May inclusive.

Central New York Roentgen Ray Society
Secretary, Dr. Dwight V. Needham, 608 E. Genesee St., Syracuse N. Y. Meets January, May, November.

Central Ohio Radiological Society
Secretary, Dr. Paul D. Meyer, Grant Hospital, Columbus, Ohio. Meets at 6:30 P.M. on second Thursday of October, December, February, April, and June at Seneca Hotel, Columbus, Ohio.

Chicago Roentgen Society
Secretary, Dr. John H. Gilmore, 720 N. Michigan Ave., Chicago 11, Ill. Meets second Thursday of each month October to April inclusive at the University Club.

Cincinnati Radiological Society
Secretary, Dr. E. C. Elsey, 927 Carew Tower, Cincinnati 2, Ohio. Meets last Monday of each month, September to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. J. R. Hannan, Cleveland Clinic, Cleveland 6, Ohio. Meetings at 6:30 P.M. on fourth Monday of each month from October to April.

Colorado Radiological Society
Secretary, Dr. Paul E. RePass, 306 Republic Bldg., Denver 2, Colo. Meets third Friday of each month at University of Colorado Medical Center or at Denver Athletic Club.

Connecticut Valley Radiologic Society
Secretary, Dr. E. W. Godfrey, 1676 Boulevard, West Hartford, Conn. Meets second Friday Oct. and April.

Dallas-Fort Worth Roentgen Study Club
Secretary, Dr. X. R. Hyde, Medical Arts Bldg., Fort Worth, Texas. Meets in Dallas on odd months and in Fort Worth on even months, on third Monday, 7:30 P.M.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. W. G. Belanger, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

East Bay Roentgen Society
Secretary, Dr. Dan Tucker, 434-30th St., Oakland 9, Calif. Meets first Thursday each month at Peralta Hospital, Oakland.

Florida Radiological Society
Secretary, Dr. F. K. Hurt, Riverside Hospital, Jacksonville, Fla. Meets twice annually, in the spring with the annual State Society meeting, and in the fall.

Georgia Radiological Society
Secretary, Dr. Robert Drane, DeRenne Apartments, Savannah, Ga. Meets in mid-winter and at annual meeting of Medical Association of Georgia in the spring.

Greater Miami Radiological Society
Secretary, Dr. David Kirsh, 712 duPont Bldg., Miami 32, Florida. Meets last Wednesday of each month at 8:00 P.M. at Veterans Administration Regional Office.

Houston X-ray Club
Secretary, Dr. Curtis H. Burge, 3020 San Jacinto St. Houston 4, Texas. Meets fourth Monday each month.

Radiological Society of Kansas City
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. William M. Loehr, 712 Hume-Mansur Bldg., Indianapolis 4. Meets second Sunday in May.

Iowa X-Ray Club
Secretary, Dr. Arthur W. Erskine, 326 Higley Bldg., Cedar Rapids, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. Special meetings by announcement.

Kansas Radiological Society
Secretary, Dr. Anthony F. Rossitto, Wichita Hospital, Wichita, Kan. Meets annually with State Medical Society.

Kentucky Radiological Society
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

Kings County Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:45 P.M.

Los Angeles Radiological Society
Secretary, Dr. Wybren Hiemstra, 1414 S. Hope St., Los Angeles 15, Calif. Meets second Wednesday each month at Los Angeles County Medical Assn. Building.

Louisiana Radiological Society
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

* Secretaries of societies are requested to send timely information promptly to the Editor.

Louisville Radiological Society
Secretary, Dr. E. L. Pirkey, Louisville General Hospital, Louisville 2, Ky. Meets monthly on second Friday at Seelbach Hotel, Louisville.

Miami Valley Radiological Society
Secretary, Dr. G. A. Nicoll, 134 Apple St., Dayton, Ohio. Meets second Friday of fall and winter months.

Michigan Association of Roentgenologists
Secretary, Dr. R. D. McDuff, 220 Genesee Bank Bldg., Flint 3, Mich.

Milwaukee Roentgen Ray Society
Secretary, Dr. T. J. Pfeffer, 839 N. Marshall St., Milwaukee 2, Wis. Meets monthly on second Monday at University Club.

Minnesota Radiological Society
Secretary, Dr. Chauncey N. Borman, 802 Medical Arts Bldg., Minneapolis 2, Minn. Two meetings yearly, one at time of Minn. State Med. Assn., the other in the fall.

Nebraska Radiological Society
Secretary, Dr. Ralph C. Moore, Nebraska Methodist Hospital, Omaha 3, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. George Levene, Massachusetts Memorial Hospitals, Boston, Mass. Meets monthly on third Friday, Harvard Club.

New Hampshire Roentgen Ray Society
Secretary, Dr. A. C. Johnston, Elliott Community Hospital, Keene, N. H. Meets four to six times yearly.

New York Roentgen Society
Secretary, Dr. F. H. Ghiselin, 111 East 76th St., New York 21, N. Y. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

North Carolina Radiological Society
Secretary, Dr. J. E. Hemphill, 1420 E. Fifth St., Charlotte 4, N. C. Meets in May and October.

North Dakota Radiological Society
Secretary, Dr. C. O. Heilman, 807 Broadway, Fargo. Meetings by announcement. Annual session with State Medical Society in May, 1950, at Grand Forks, N.D.

Northern California Radiological Club
Secretary, Dr. R. L. Ayers, 726 4th St., Marysville, Calif. Meets at dinner last Monday, every second month, except June, July and August.

Ohio State Radiological Society
Secretary, Dr. E. C. Elsey, 927 Carew Tower, Cincinnati 2, Ohio.

Oklahoma State Radiological Society
Secretary, Dr. W. E. Brown, Tulsa, Okla. Three regular meetings annually.

Oregon Radiological Society
Secretary, Dr. Selma Hyman, Univ. of Oregon Medical School, Portland, Oregon. Meets monthly 2nd Wednesday, 8:00 P.M.

Orleans Parish Radiological Society
Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets first Tuesday of each month.

Pacific Northwest Radiological Society
Secretary, Dr. S. J. Hawley, 1320 Madison St., Seattle 4, Wash. Meets annually in May.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. J. M. Converse, 416 Pine St., Williamsport. Annual Meeting: Penn Harris Hotel, Harrisburg, Pa., May 12–13, 1950.

Philadelphia Roentgen Ray Society
Secretary, Dr. G. P. Keefer, 1930 Chestnut St. Meets first Thursday each month October to May, at 8:00 P.M., in Thomson Hall, College of Physicians.

Pittsburgh Roentgen Society
Secretary Dr. E. J. Euphrat, 3500 Fifth Ave., Pittsburgh 13, Pa. Meets 6:30 P.M. at Webster Hall Hotel on second Wednesday each month, October to May inclusive.

Queens Roentgen Ray Society
Secretary, Dr. J. E. Goldstein, 88-29 163rd St., Jamaica 3, N. Y. Meets fourth Monday of each month except during the summer.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Harry A. Miller, 2452 Eutaw Place, Baltimore. Meets third Tuesday each month, Sept. to May.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Fred Zaff, 135 Whitney Ave., New Haven, Conn. Meets bimonthly on second Wednesday.

Radiological Section, District of Columbia Medical Society
Secretary, Dr. K. C. Corley, 1835 Eye St., N. W., Washington, D. C. Meets Medical Society Auditorium, third Thursday, Jan., March, May, Oct. at 8:00 P.M.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Radiological Society of New Jersey
Secretary, Dr. Benjamin Copleman, 280 Hobart St., Perth Amboy, N. J. Meets annually at Atlantic City at time of State Medical Society and mid-winter at Elizabeth, N. J.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. A. V. Winchell, 40 Meigs St., Rochester, N. Y. Meets monthly on last Monday from September through May, 8 P.M. at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary, Dr. Maurice D. Frazer, 1037 Stuart Bldg., Lincoln, Nebr.

St. Louis Society of Radiologists
Secretary, Dr. H. R. Senturia, Pasteur Medical Building, St. Louis, Mo. Meets fourth Wednesday each month, except June, July, August, and September.

San Diego Roentgen Society
Secretary, Dr. R. F. Niehaus, 1831 Fourth Ave., San Diego, Calif. Meets monthly, first Wednesday at dinner.

Section on Radiology, California Medical Association
Secretary, Dr. D. R. MacColl, 2007 Wilshire Blvd., Los Angeles 5, Calif.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. Harold L. Shinall, St. Joseph's Hospital, Bloomington, Ill.

Shreveport Radiological Club
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston first Thursday in November, also with South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. R. P. O'Bannon, 650 Fifth Ave., Fort Worth 4, Texas. Next meeting, Dallas, Texas, February 3 and 4, 1950.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets first and third Thursdays 4:00 to 5:00 P.M., September to May inclusive. Room 203, Service Memorial Institute, 426 N. Charter St., Madison.

Utah State Radiological Society
Secretary, Dr. Angus K. Wilson, 343 S. Main St., Salt Lake City 1, Utah. Meets third Wednesday in September, November, January, March and May.

Virginia Radiological Society
Secretary, Dr. P. B. Parsons, Norfolk General Hospital, Norfolk, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. J. H. Walker, 1115 Terry Ave., Seattle 1, Wash. Meets fourth Monday each month, October through May, College Club, Seattle.

Wisconsin Radiological Society
Secretary, Dr. Irving I. Cowan, 425 E. Wisconsin Ave., Milwaukee 2, Wis. Special meetings held during year; annual meeting each spring at Madison, Wis.

X-Ray Study Club of San Francisco
Secretary, Dr. W. F. Reynolds, University of California Hospital, San Francisco. Meets from January to July at Lane Hall, Stanford University Hospital, and from July to December at San Francisco Hospital.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

Mexico

Sociedad Mexicana de Radiologia y Fisioterapia
General Secretary, Dr. D. P. Cossio, Marsella No. 11, Mexico, D. F. Meets first Monday of each month.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Ordinary meeting, on the Thursday preceding the third Friday, October to May at 8:15 p.m.
Medical Members' meeting, on third Friday in each month at 5:00 p.m., 32 Welbeck St., London, W 1.

Faculty of Radiologists
Honorary Secretary, Dr. J. F. Bromley, 45, Lincoln's Inn Fields, London, W.C.2, England.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets third Friday each month at 4:45 p.m. at the Royal Society of Medicine, 1 Wimpole St., London.

Canadian Association of Radiologists
Honorary Secretary, Dr. E. M. Crawford, 1535 Sherbrooke St., West, Montreal 26, Que. Meetings January and June.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Société Canadienne-Française d'Electrologie et de Radiologie Médicales
Secretary, Dr. Origéne Dufresne, 4120 Ontario St., East, Montreal, P. Q.

Australian and New Zealand Association of Radiologists
Honorary Secretary, Dr. Alan R. Colwell, 135 Macquarie St., Sydney, N.S.W.
Honorary Secretaries, State Branches:
New South Wales, Dr. E. W. Frecker, 135 Macquarie St., Sydney.
Victoria, Dr. T. I. Tyrer, 3 Lockerbie Court, East St. Kilda.
Queensland, Dr. J. Adam, 131 Wickham Terrace, Brisbane.
South Australia, Dr. R. de G. Burnard, 170 North Terrace, Adelaide.
Western Australia, Dr. A. M. Nelson, 179-B St. Georges Terrace, Perth.
New Zealand, Dr. E. G. Lynch, 12 Bolton St., Wellington.

South America

Asociacion Argentina de Radiologia
Secretary, Dr. Lidio G. Mocsa, Avda. Gral Paz 151, Córdoba, Argentina. Meetings held monthly.

Sociedad Argentina de Radiologia
Secretary, Dr. Guido Gotta, Buenos Aires, Argentina. Meetings are held monthly.

Sociedad Argentina de Radiología, Filial del Litoral
President, Dr. Francisco P. Cifarelli. Meets monthly second Wednesday, 7:00 p.m., 663 Italia St., Rosario.

Sociedade Brasileira de Radiologia Medica
Secretary, Dr. Nicola Caminha, Av. Mem de Sa, Rio de Janeiro, Brazil. Meets monthly, except during January, February and March.

Sociedade Brasileira de Radioterapia
Secretary, Dr. Oscar Rocha von Pfuhl, Av. Brigadeiro Luiz Antonio, 644 São Paulo, Brazil. Meets monthly on second Wednesday at 9 p.m. in São Paulo at Av. Brigadeiro Luiz Antonio, 644.

Sociedad Peruana de Radiologia
Secretary, Dr. Julio Bedoya Paredes, Apartado, 2306, Lima, Peru. Meets monthly except during January, February and March, at Asociación Médica Peruana "Daniel A. Carrión," Villalta, 218, Lima.

Sociedad de Radiologica, Cancerologia y Fisica Medica del Uruguay
Secretary, Dr. Arias Bellini.

Continental Europe

Société Belge de Radiologie
General Secretary, Dr. S. Masy, 111 Avenue des Alliés, Louvain, Belgium. Meets monthly, second Sunday at Maison des Médecins, Brussels.

Ceskoslovenská společnost pro röntgenologii a radiologii v Praze
Secretary, Dr. Roman Bláha, Praha XII, stát. nemocnice, Czechoslovakia. Meets monthly except during July, August, and September. Annual general meeting.

Polish Society of Radiology
Secretary, Dr. L. Zgliczynski, 59 Nowogrodzka St., Warsaw, Poland.

Gdansk Section, Polish Society of Radiology
Secretary, Dr. A. Smigielska, Akademia Lekarska, Gdansk. Meets monthly last Sunday at 10.30, X-Ray Dept., Akademia Gdansk.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. L. Zgliczynski, 59 Nowogrodzka St., Warsaw, Poland. Meets monthly.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banual Măräcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad. USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 p.m.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Schweizerische Röntgen-Gesellschaft (Société Suisse de Radiologie)
Secretary, Dr. Max Hopf, Effingerstrasse 47, Bern, Switzerland.

Societa Italiana di Radiologia Medica
Secretary, Prof. Mario Ponzio, Ospedale Mauriziano. Torino, Italy. Meets biannually.

NEW FUNDS AVAILABLE FOR RADIOLOGICAL RESEARCH

The National Research Council announces the availability of funds for fundamental research in the field of radiology. This has been made possible by the James Picker Foundation, established in 1947 by Mr. Picker and his family. Capital funds of the Foundation now approximate $400,000.

The announced objectives of the James Picker Foundation are "to provide funds to foster research and broaden the scope of radiology."

For the year 1950, $15,000 from income will be available for research. In allocating these funds, special consideration will be given to fundamental work in radiology and its applied fields. The Foundation has specifically requested that none of its funds be used to subsidize the development of radiological equipment.

The National Research Council has been designated as the scientific advisory body of the Foundation. It is expected that applications will be considered by the Council's Committee on Radiology under the Chairmanship of Dr. Eugene P. Pendergrass. Final determination of the awards will be made by the Directors of the Foundation upon the recommendation of the National Research Council.

The Directors of the James Picker Foundation are: Harold E. Stassen (Chairman)—President, University of Pennsylvania

General Georges Doriot—Professor, Harvard University

Ivan Dresser—Vice President, General Motors Overseas Corporation

Ross Golden, M.D.—Professor of Radiology, College of Physicians and Surgeons, Columbia University

Applications for fellowships in the field of radiological research, with stipends of the order of $3,000 to $5,000, depending upon the qualifications and special circumstances of the applicant, will also be entertained.

Applications for research grants and fellowships available during the year beginning January 1, 1915, will be entertained until September 15, 1950, and are *not* limited to citizens of or laboratories in the United States.

Inquiries should be addressed to Secretary, Division of Medical Sciences, National Research Council, 2101 Constitution Avenue, Washington 25, D. C.

THEORETICAL AND PRACTICAL COURSE OF COMPLEMENTARY AND ADVANCED STUDY IN STRATIGRAPHY

A post-graduate course on the theory and practice of stratigraphy will be given under the direction of Professor Allessandro Vallebona at the Institute of Radiology of the University of Genoa.

The course will cover a period of ten days from September 1 to 10, 1950.

The course will consist of conferences, lectures, demonstrations, and practical exercises. The various subjects will be presented by the personnel of the Institute of Radiology, but Italian and foreign specialists will also be invited to give conferences and lectures.

An exhibit of stratigraphic apparatus will be held during the time of the course.

Italian and foreign physicians may register for the course which will be given in Italian and French. The registration should be applied for before June for organizational reasons. A detailed program showing the schedule of the lectures and the names of the lecturers will be sent to the physicians who have registered for the course. A certificate of attendance will be given to the participants of the course.

PROGRAM

History of stratigraphy
Fundamental physical principles
Stratigraphic apparatus
Frontal stratigraphy
Sagittal stratigraphy
Transverse axial stratigraphy
Clinical applications of the stratigraphic method
Normal respiratory apparatus
Pulmonary tuberculosis
Other inflammatory processes of the lung
Pleural and pulmonary tumors
Normal mediastinum
Pathology of the mediastinum
Diseases of the heart and great vessels
Normal and pathologic diaphragm

Abdominal organs
Normal skeleton
Pathology of skull
Pathology of the vertebral column
Pathology of pelvis
Urinary apparatus
Stratigraphy in pediatrics
Various applications of stratigraphy
Relationship between normal roentgen investigation and stratigraphy

For registration or information, please address the Secretary, Dr. P. Amisano, Istituto di Radiologia dell'Università, Ospedale S. Martino, Genova, Italy.

PACIFIC NORTHWEST RADIOLOGICAL SOCIETY

The annual meeting of the Pacific Northwest Radiological Society is to be held at the Spokane Hotel, Spokane, Washington, May 6 and 7, 1950. Dr. Merrill C. Sosman and Dr. J. A. del Regato are to be the guest speakers. Dr. Sosman is to speak on "Diagnosis of Skull and Intracranial Disorders" and "Diagnosis of Heart Disease." Dr. del Regato will speak on "Cancer of the Lower Lip" and "Treatment of Carcinoma of the Cervix." There will be additional talks given by the members of the Society and an interesting film discussion is promised for Sunday morning. Any non-members interested in the meeting are invited to attend.

MIAMI VALLEY RADIOLOGICAL SOCIETY

The radiologists of Dayton, Springfield, Middletown and Hamilton, Ohio, and Richmond, Indiana, met in Dayton on February 10, 1950. The Miami Valley Radiological Society was organized and the following officers were elected for 1950: *President*, Dr. A. W. Marcovich; *Vice-President*, Dr. F. A. Bavendam; *Secretary-Treasurer*, Dr. George A. Nicoll. The Society plans to meet the second Friday of the fall and winter months.

MEDICAL MEETINGS IN HOUSTON, TEXAS

Meetings of interest to scientists and physicians at the Texas Medical Center, Houston, Texas, May 12–13, 1950. Featured speakers will be Dr. A. C. Broders of the Mayo Clinic, Dr. Marshall Brucer of the Oak Ridge Institute of Nuclear Studies, and Dr. C. P. Rhoads of the Memorial Hospital, New York City. The meetings include:

1. The fourth annual "Symposium on Fundamental Cancer Research," of The University of Texas, M. D. Anderson Hospital for Cancer Research, during which one-half day will be devoted to selected papers on the subject of isotopes in cancer research.
2. A Cancer Pathology Conference of The University of Texas Postgraduate School of Medicine, on "Tumors of Muscle Origin."
3. A South Central Regional Meeting of the College of American Pathologists, with co-participation in the symposium and pathology conference.

Dr. C. P. Rhoads will be the banquet speaker on the evening of May 12. Further information may be obtained from William O. Russell, M.D., 2310 Baldwin Street, Houston, Texas.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

Précis de Technique Radiographique. By P. Porcher, Médecin Radiologiste de l'Hôpital Saint-Antoine et de l'Hôpital Américain. Second edition, completely revised. Ouvrage Couronné par l'Académie des Sciences (Prix Montyon 1939, Mention honorable). Cloth. Price, 3500 fr. Pp. 508, with 431 illustrations. Paris: Gauthier-Villars, 1948.

The first edition of this book appeared in 1938 and won the 1939 *Prix Montyon* awarded by the Academy of Sciences. The present second edition is superior in many ways to the prize-winning first edition. There is a new format, there are many new illustrations, there is more detailed text with nearly twice the number of pages. However, the book still remains a *practical* guide covering all the useful roentgenographic positions and maneuvers necessary in conventional roentgenography only, i.e., roentgenographic technique not requiring special roentgen-ray apparatus.

Part I is devoted to roentgenographic technique of the skeleton: cranium, facial bones, sinuses, teeth, thoracic cage, vertebral column, pelvis, extremities and articulations, and a section on soft tissues. This makes up about one-half of the book and the reader will find many alternate positions detailed under each particular part; for example, twelve positions for study of the elbow joint and eight special positions other than the routine views for the wrist, many of these special views making use of the curved film holder. Part I also contains special positioning as in ventriculographic, encephalographic, myelographic, arthrographic, and cerebral arteriographic examinations.

Part II covers Technique for Examination of the Viscera: digestive tract and neighboring organs (one of the most remarkable sections of the entire book), urinary and genital tract, respiratory, and circulatory system. It is in Part II that the French manual of technique differs so much from its American counterpart for the American manual is written almost exclusively for the roentgen-ray technician and with a minimum of clinical consideration and detailed critical study of the clinical aspects of various procedures. The French manual is written almost exclusively for the radiologist who far more often than in America is his own technician. Consequently, the second part of the book contains samples of the author's printed instructions for preparation of patients for different examinations (cholecystography, urography, barium enema, etc.), critical study of types of examination of the stomach with ulcer, the cancerous stomach or stomach presumed so, the stomach after surgery, the surgical lung, and portable film work at the bedside. It is this feature that should make the book so valuable to American roentgenologists with a reading knowledge of French. In addition, the last 16 pages are devoted to emergency roentgenographic examinations and special technical procedures in major traumatic cases (skull, spine, etc.), subjects which are of particular interest to this author for he recently collaborated with Prof. H. Mondor and Dr. C. Olivier in writing a special monograph entitled "Emergency Roentgen Diagnosis" (Masson et Cie, Paris, 1943).

The publisher is to be congratulated on the magnificent job of book making and in particular for preparing such a splendid edition while keeping the price so reasonable.

It would seem that Dr. Porcher, in preparing such an excellent text for present-day roentgenologists, has kept faith with his beloved maître, Henri Béclère, who accomplished so much for the progress of roentgenographic technique.

William M. Loehr, M.D.

Roentgen Diagnosis of the Extremities and Spine. (Annals of Roentgenology, Volume XVII.) By Albert B. Ferguson, M.D., Associate Professor, Orthopaedic and Fracture Surgery, Boston University; Consulting Roentgenologist, Children's and Memorial Hospitals, Boston; formerly Director of Roentgenology, New York Orthopaedic Hospital. Second edition, revised and enlarged. Cloth. Price, $15.00. Pp. 519, with 633 illustrations. New York: Paul B. Hoeber, Inc., 1949.

This volume of the Annals of Roentgenology

is a revised and enlarged second edition of the author's earlier book on "Roentgen Diagnosis of the Extremities and Spine" published in 1939. Few alterations in the text have been made. Dr. Ferguson has completed a ten year study of the Registry of Bone Sarcoma and from the results of this study he has selected a number of useful and reliable observations pertaining to the common bone malignancies, especially osteogenic sarcoma, Ewing's sarcoma and multiple myeloma. This material he presents in an additional two chapters and seventy-one illustrations which expands the book by almost a quarter of its original size.

In the arrangement of the text, the author adheres to the belief expressed in the preface of his first edition that the differentiation of common conditions is a topic sufficiently voluminous and important to be the sole subject of the entire text. He states that since exhaustive compilation which covers every phase of every lesion would demand a separate volume for each disease and each region of the body, he has confined the text to material of diagnostic utility. No attempt is made to treat separate disease conditions exhaustively from all points of view. The reproductions of roentgenograms are again printed positives, uniform throughout, however, to which objection may be made by some readers. No references to the literature are given. At the end of each chapter, short case histories are listed for each reproduced roentgenogram.

The specialized terminology employed in the first edition is again used and the terms appear in bold face type to arrest the reader's attention. In the two chapters which are added, many new original terms are used. Thus for location of tumors in individual bones, terms such as epigrade, arthrograde, metagrade, primograde, etc., are encountered. Because of its form the book requires careful and thoughtful reading with too frequent reference to the definitions of the terms used, resulting in constant interruption while reading.

Even if the reader may disagree with some of the opinions of the author, and may find that the rather unusual approach to the subject requires extremely careful study while reading, the wealth of the illustrations compensates for the time spent, and makes the book a useful and valuable addition to the roentgenologist's library.

R. S. Bromer, M.D.

The Arthropathies: A Handbook of Roentgen Diagnosis. By Alfred A. de Lorimier, M.D., Radiologist, Saint Francis Hospital, San Francisco; Consultant in Radiology for the United States Army at Letterman General Hospital; formerly Commandant, The Army School of Roentgenology. Second edition. Cloth. Price, $7.00. Pp. 335, with 157 illustrations. Chicago: The Year Book Publishers, Inc., 1949.

In the second edition of this Handbook on the Arthropathies, Dr. de Lorimier has provided new reproductions without the wavy arrows which were so conspicuous in the first edition. He has retained the original outline, with descriptions of roentgen features, followed by considerations of the periarticular soft tissues, nearby osseous structure, osseous articular cortexes and then the various components of the joints themselves. He believes it is essential to emphasize, in this manner, the importance of a routine analysis and to counteract the prevalent practice of considering merely the bony outlines of a joint. He has included points of clinical and laboratory corroboration because too often the roentgen findings are not by themselves distinctive.

The book is again of small size with legible print, corresponding to the other books of the Handbook Series. The illustrations, many of which are retained from the first edition, consist of roentgenograms, diagrams and histopathologic sections. The classification of joint conditions is again based on etiologic considerations. The bibliography is ample.

The changes made add to the attractiveness of the book and also to its usefulness and ease of reading and study. It will again prove to be a valuable book for the student and roentgenologist for ready reference and diagnostic criteria.

Ralph S. Bromer, M.D.

Recent Advances in Oto-Laryngology. By R. Scott Stevenson, M.D., Ch.B., F.R.C.S. (Ed.), Surgeon, Metropolitan Ear, Nose and Throat Hospital; Consulting Laryngologist, Colindale, Pinewood, Preston Hall and other Tuberculosis Hospitals; President, Section of Otology, Royal Society of Medicine. Second edition. Cloth. Price, $6.00. Pp. 395, with 106 illustrations and 8 plates. Philadelphia: The Blakiston Company, 1949.

This small book on recent advances in oto-

laryngology is most unusual and it should be of great value to the practicing otolaryngologist. As a matter of fact, it is of interest to the radiologist because it gives him a bird's eye view of one field in which he is very much interested. The author has a wide fund of knowledge because he has not only included discussions of surgical and chemotherapeutic treatment of lesions involving the sinuses and upper respiratory tract, but also a brief discussion of the roentgen diagnosis and radiation therapy of the sinuses and the upper respiratory tract. The book is well illustrated and should serve a useful purpose to a wide variety of medical practitioners including general practitioners, otolaryngologists and radiologists.

Eugene P. Pendergrass, M.D.

Tratto di Roentgen- e di Curie-Terapia. Diretto da Felice Perussia e da Enzo Pugno-Vanoni. Volume II. Second edition. Cloth. Price, Lire 8000. Pp. 1054, with 465 illustrations, 5 of which are in color. Garzanti, Via Della Spiga, 30, Milan, Italy, 1948.

This book is the second volume of a treatise on roentgen therapy compiled by an outstanding roentgen therapist and an outstanding radiation physicist. The first volume, which appeared last year, dealt with the physical bases of roentgen and radium therapy, and the second volume deals with the clinical applications of radiant energy.

The chapter on general effects of radiation was written by Prof. Perussia, himself, who is the director of the Cancer Institute at the University of Milan. Prof. Perussia also wrote the chapter on roentgen therapy in dermatology, which concludes the book. The other chapters were written by radiologists who have been closely associated with Perussia and his work. Roentgen therapy of tumors was assigned to A. Ratti, and roentgen therapy of uterine myomata is described by E. Bortini. Roentgen therapy of inflammatory diseases was assigned to O. Alberti and F. Cardillo. Roentgen therapy of tuberculosis is discussed by G. Giraudi and P. L. Cova. The chapter on roentgen therapy of hemopoietic organs was assigned to G. Meda. Roentgen therapy of allergic and metabolic diseases is discussed by M. Pellini. Roentgen therapy of the internal secretion disturbances and diseases of the central nervous system is discussed by F. Mascherpa. G. Giraudi wrote the chapter on roentgen therapy of disease of the bone and joints.

In a book of this kind, it is almost impossible to avoid a certain amount of overlapping. However, the division of the subjects seems very well done, and each of the authors is a recognized expert in his field. Of particular interest to American radiologists are the indications and results of roentgen therapy in diseases which are relatively uncommon in the United States, such as lupus vulgaris, leishmaniasis, and tuberculous diseases of bones, joints and lymph glands. Regarding therapy of universally common diseases, the Italian radiologists are in the fortunate position of being subjected about equally to the influence of English, German, French and Swedish literature. Being endowed with a critical and analytical mind, they are in the position of choosing the best available and blending it with their own experiences. The result is very satisfactory inasmuch as it gives the reader a chance to review what has been done on a subject everywhere and then learn in concrete fashion what is being recommended by the various authors.

Prof. Perussia can be proud of this book. These two volumes constitute a compilation made with discernment and critical spirit which fill a definite place in Italian medical literature. The book is well illustrated and well printed.

Cesare Gianturco, M.D.

Die Röntgenbildanalyse. Eine Röntgendiagnostische Anleitung für Studierende und Ärzte. By Dr. Erich Saupe. Second edition, fully revised by Dr. W. E. Baensch, Professor of Radiology, Georgetown University Medical Center and Georgetown University Hospital. Pp. 244, with 224 illustrations. Stuttgart: Georg Thieme, 1949.

The original text prepared by the late Dr. Erich Saupe, who died several years ago, was based on a number of well known German publications, including the book of Alban Köhler on "The Normal and Borderlands of Pathology in Roentgenograms"; Grashey's "Atlas of Normal and Pathological Roentgenograms"; and the more pretentious books by Schinz, Baensch and Friedl; Assmann; Haenisch and Holthusen; Groedel-Lossen, and others, as well as many articles which appeared in *Röntgenpraxis*, *Fortschritte auf dem Gebiete der Röntgenstrahlen*, and *Zentralblatt für die gesamte Radi-*

ologie. The present edition has been fully and completely revised by Dr. Baensch. There is a profusion of illustrations which are beautifully reproduced. The press work in this book is of a very high order.

Following a chapter on general roentgenology, the main portion of the work, consisting of about two hundred pages, is devoted to roentgen diagnosis. The text is prepared in a very orderly manner, which leaves very little to be desired.

James T. Case, M.D.

Electronics: Experimental Techniques. By William C. Elmore, Associate Professor of Physics, Swarthmore College; and Matthew Sands, Assistant Professor of Physics, Massachusetts Institute of Technology. First edition. Cloth. Price, $3.75. Pp. 417, with numerous illustrations. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, 18, New York, 1949.

This manual describes a large number of circuits for the nuclear research laboratory although many of the techniques presented are useful in other related fields. Starting with a short and fundamental review of the components of electronic circuits and the common practices of circuit construction, the authors present the various circuit elements from simple resistance-capacitance networks to various trigger circuits. These introductions are followed by chapters on voltage amplifiers, electronic counters, oscillographs, test and calibration equipment, power supplies and control circuits. The book is well written and contains a wealth of useful information for radiologists interested in the construction of instruments for nuclear studies.

Otto Glasser, Ph.D.

BOOKS RECEIVED

Manuel de Radiodiagnostic Clinique. Par R. Ledoux-Lebard, Chargé de Cours de Radiologie clinique à la Faculté de Médecine de Paris, Radiologiste des Hôpitaux; et Guy-R. Ledoux-Lebard, Ancien chef de Clinique à la Faculté de Médecine de Paris, Assistant de Radiologie des Hôpitaux. Deuxième édition entièrement refondue. Cloth. Price, 5500 fr. Pp. 1,407, with 2,000 illustrations. Paris: Masson et Cie., 1949.

Recent Advances in Oto-Laryngology. By Scott Stevenson, M.D., Ch.B., F.R.C.S. (Ed.), Surgeon, Metropolitan Ear, Nose and Throat Hospital; Consulting Laryngologist, Colindale, Pinewood, Preston Hall and other Tuberculosis Hospitals; President, Section of Otology, Royal Society of Medicine. Second edition. Cloth. Price, $6.00. Pp. 395, with 106 illustrations and 8 plates. Philadelphia: The Blakiston Company, 1949.

Schilddrüse und Basedow. Beiträge zur Histo-Morphologie und Funktion der Schilddrüse verschiedener freilebender Tiere. Von Prof. Dr. med. Wilhelm Eickhoff, Rheine/Westfalen. Cardboard. Price, DM 10.80. Pp. 127, with 42 illustrations. Stuttgart: Georg Thieme, 1949.

Congenital Anomalies of the Heart and Great Vessels. Clinicopathologic Study of 132 Cases. By Thomas J. Dry, Robert L. Parker, H. Milton Rogers, Jesse E. Edwards, Howard B. Burchell, and Arthur H. Bulbulian of the Mayo Clinic. Cloth. Price, $4.50. Pp. 68, with 80 illustrations. Springfield, Illinois: Charles C Thomas, 1949.

Tomografía clínica cardio-vascular. Biblioteca del Médico Prático, Vol. XXIX. Por los doctores Juan Govea, Cardiólogo—Hospital Mercedes, Habana; y Fidel Aguirre, Radiólogo—Instituto del Radiums, Hospital Mercedes, Habana. Cloth. Price, $8.00. Pp. 482, with 308 illustrations. La Habana: Cultural, S. A., 1949.

Roentgen-Ray Examination of the Digestive Tract. By Ross Golden, M.D., Professor of Radiology, The College of Physicians and Surgeons, Columbia University; Director of the Department of Radiologic Service, The Presbyterian Hospital, New York. Cloth. Price, $5.00. Pp. 358, with 117 illustrations. New York: Thomas Nelson & Sons, 1949.

Intestinal Intubation. By Meyer O. Cantor, M.D., M.S., F.A.C.S., Assistant Attending Surgeon, Grace Hospital; Formerly, Senior Attending Surgeon, Deaconess Hospital, Detroit, Michigan. Cloth. Price, $7.50. Pp. 333, with 147 illustrations. Springfield, Illinois: Charles C Thomas, 1949.

Collectio Radiographica Cranii et Cerebri I. Craniopharyngioma. (In Lingua Anglica, Gallica, Germanica, Hungarica.) By Ludovicus Haas, Docens Universitatis

Scientiarum Budapestinensis, Primarius Roentgenologiae Nosocomii Municipalis "Korányi." Paper. Pp. 39, with 23 illustrations. Budapest: Magyar Orvosok Szabad Szakszervezete, 1948.

Myelography with Water-Soluble Contrast, with Special Regard to the Normal Roentgenpicture. Acta Radiologica, Supplementum LXXV. By Sigfrid Arnell, Chief, Roentgenological Department, Lasarettet, Gävle. Paper. Pp. 85, with 61 illustrations. Stockholm: Esselte Aktiebolag, 1949.

An Atlas of Myelography. Prepared for the Registry of Radiologic Pathology, American Registry of Pathology, National Research Council, from Material in the Files of the Neurological Institute of New York. By Ernest H. Wood, Jr., M.D., Assistant Professor of Radiology in the College of Physicians and Surgeons, Columbia University; Assistant Attending Radiologist to the Presbyterian Hospital of the City of New York. Cloth. Pp. 111, with numerous illustrations. Washington: Registry Press, 1948.

Die Röntgendiagnostik der Wirbelsäule und ihre Grundlagen. Von Dr. Med. Adolf Liechti, Professor für Medizinische Radiologie, Direktor des Röntgeninstitutes der Universität Bern. Zweite, neubearbeitete und ergänzte Auflage. Paper. Price, $13.00. Pp. 364, with 234 illustrations. Wien: Springer-Verlag, 1948.

Die Pathologie des Harnleiters im Röntgenbild. Von Privatdozent Dr. Anton Thelen. Paper. Pp. 87, with 71 illustrations. Stuttgart: Georg Thieme, 1949.

Trattato de Roentgen- e di Curie-Terapia. Diretto da Felice Perussia e da Enzo Pugno-Vanoni. Volume II. Second edition. Cloth. Price, Lire 8000. Pp. 1,054, with 465 illustrations, 5 of which are in color. Milano: Garzanti, 1948.

Cancer. Hérédité-Hormones-Substances Cancérigenes. Tome I. Par Docteur J. Maisin, Professeur à l'Université de Louvain, Directeur de l'Institut du Cancer. Paper. Price, Francs 84.00. Pp. 284, with numerous illustrations. Tournai-Paris: Casterman, 1948.

Röntgen- und Radiumphysik für Mediziner. Von Dr. Richard Glocker, Professor für Röntgentechnik an der Technischen Hochschule Stuttgart. Cloth. Price, DM 19.80. Pp. 275, with 167 illustrations. Stuttgart: Georg Thieme, 1949.

Electronics: Experimental Techniques. By William C. Elmore, Associate Professor of Physics, Swarthmore College; and Matthew Sands, Assistant Professor of Physics, Massachusetts Institute of Technology. First edition. Cloth. Price, $3.75. Pp. 417, with numerous illustrations. New York: McGraw-Hill Book Company, Inc., 1949.

Ionization Chambers and Counters. Experimental Techniques. By Bruno B. Rossi, Professor of Physics, Massachusetts Institute of Technology; and Hans H. Staub, Professor of Physics, Stanford University. First edition. Cloth. Price, $2.25. Pp. 243, with numerous illustrations and tables. New York: McGraw-Hill Book Company, Inc., 1949.

Handbook of Materia Medica, Toxicology, and Pharmacology. For Students and Practitioners of Medicine. By Forrest Ramon Davison, B.A., M.Sc., Ph.D., M.B., Consultant and Toxicologist, Minneapolis; Formerly Assistant Professor of Pharmacology in the School of Medicine, University of Arkansas; etc. Fourth edition. Cloth. Price, $8.50. Pp. 730, with 35 illustrations. St. Louis: C. V. Mosby Company, 1949.

Brookhaven Conference Report. Biological Applications of Nuclear Physics. July 12–27, 1948. Paper. Price, $1.50. Pp. 154, with 67 illustrations and 32 tables. Upton, New York: Brookhaven National Laboratory, Associated Universities, Inc., 1948.

Experimental Untersuchungen über Röntgeneffekte und chemische Effekte auf die pflanzliche Mitose. Von Dr. Med. Kurt Hohl. Paper. Pp. 87, with 30 illustrations and tables. Stuttgart: Georg Thieme, 1949.

ABSTRACTS OF RADIOLOGICAL LITERATURE

Department Editor: T. Leucutia, M. D., Harper Hospital, Detroit 1, Michigan

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ROENTGEN DIAGNOSIS

ABDOMEN

Frazer, A. C., French, J. M., and Thompson, M. D. Radiographic studies showing the induction of a segmentation pattern in the small intestine in normal human subjects. *Brit. J. Radiol.*, March, 1949, *22*, 123–136.

The so-called "deficiency pattern" of the small intestine following barium meal is characterized by separation of the barium column into elongated masses (segmentation) and smoothing of the intestinal contours and obliteration of the markings of the valvulae conniventes (especially in the jejunum). The segmentation pattern is associated with many clinical pathologic conditions, but may be seen in normal infants and occasionally in normal adults.

An attempt was made to induce abnormal intestinal patterns such as segmentation in normal human subjects. Intraduodenal or oral administration of barium with various substances added was employed in normal human volunteers after a twelve hour starvation period. Serial roentgenograms were made. The results were as follows: (1) Barium sulfate suspension in water alone produced a normal roentgenographic pattern in all cases in which significant changes were subsequently produced. (2) *Isotonic* solutions of sodium chloride, sodium bicarbonate and glucose with the barium suspension did not cause segmentation, although there was some coarsening of the pattern with the sodium chloride. *Hypertonic* solutions of the same substances mixed with the barium, all caused marked segmentation, similar to that of the "deficiency pattern." (3) The addition of 0.1, per cent hydrochloric acid to the barium suspension did not change the normal pattern while 0.3 per cent acetic acid, 1 per cent lactic acid and M/6 sodium lactate produced marked segmentation. (4) Hydrolyzed fat and fecal fat from cases of tropical and non-tropical sprue, produced segmentation of a marked degree.

Experiments, *in vitro*, were then performed to study the role of flocculation of the barium suspension in the production of the segmentation. It was found that flocculation occurred because of the secretion of mucus by the intestinal mucosa, the degree of flocculation being proportionate to the amount of mucus. Fatty acids and hypertonic solutions produce their effect by stimulation of mucous secretion by the intestine. Evidence is presented against the theory of neuromuscular imbalance as the cause of the segmentation pattern, i.e. clumping or segmentation was produced in a section of jejunum removed at autopsy.

It is concluded that the diagnosis of vitamin deficiency or disordered motor function of the intestine should be made cautiously, unless the possibility of flocculation of the barium meal by stomach or intestinal contents has been excluded.—*Harold Fulton, M.D.*

GYNECOLOGY AND OBSTETRICS

Hartley, J. Blair. Note on the estimation of the bi-spinous diameter in pelvimetry. *Brit. J. Radiol.*, March, 1949, *22*, 156–157.

The true bi-spinous diameter of the female pelvis as seen in the routine anteroposterior view of the pelvis lies in the plane about one-third of the pubes-table top distance. Correcting the bi-spinous diameter as measured on a routine film by assuming that the plane of the diameter is $\frac{1}{3} \times$ pubes-table length will lead to an error of about 0.05 inch. This fact has been determined by the author by use of antero-

posterior films taken at the plane determined by measurement of the patient and at levels 1.0 cm. above and below this level. The precise level at which the diameter should be measured is thus determined, but in routine work body section films are unnecessary as the correlation between the two methods is so close.—*Harold Fulton, M.D.*

NERVOUS SYSTEM

Alexander, Eben, and James, Robert M. Neurofibroma; benign intraspinal-intrathoracic hour glass tumor with paraplegia. *Ann. Surg.*, Feb., 1949, *129*, 267–273.

The writers report the case of a thirty-five year old male with paralysis of the legs who was at first thought to have a bronchogenic carcinoma with rib destruction and a secondary involvement of the spinal cord. The chest film in this case revealed a large smooth mass projecting into the superior mesial lung field on the left side. When the patient was explored, it was found that he was suffering from a benign neurofibroma of the dorsal spine with hourglass extension into the thoracic cavity. The danger of subjecting such tumors in the thorax or spine to intensive radiation therapy without adequate histopathological diagnosis is emphasized.—*C. L. Hinkel, M.D.*

Halper, Howard. Chordomata. *Brit. J. Radiol.* Feb., 1949, *22*, 88–89.

Chordomata may arise anywhere along the notochord from the sphenoccipital area, where about 40 per cent occur, to the sacrococcygeal articulation, and about 50 per cent occur in the sacrum. They may be found at birth but are usually present in the fourth or fifth decade, usually in men. The cranial cases are infrequently diagnosed, but in the nasopharyngeal or cervical regions irregular mottling or destruction of bone associated with a soft tissue tumor should suggest this possibility.

The appearances in the sacrum are characteristic. A palpable mass is usually found first. The bone changes are: expansion of the sacrum; rarefaction or destruction of bone, which may be uniform or lobulated; trabeculation formed by the undestroyed bone, and this may extend beyond the original boundary of the sacrum into the soft tissue mass; calcification occurs in irregular masses either as new bone or as faint deposits in the tumor mass itself.—*E. F. Lang, M.D.*

SKELETAL SYSTEM

Bailey, E. T. Osteogenesis imperfecta in father and son. *Proc. Roy. Soc. Med.*, London, April, 1949, *42*, 279.

The occurrence of osteogenesis imperfecta in a forty-three year old man and his nine year old son is reported. Other than stating that he could only walk on his knees no description of the father's pathology is given. The son has a history of multiple fractures of upper and lower extremities commencing with a fracture of the tibia at six months of age. By the age of six years he had sustained fourteen fractures of the arms and legs. Fractures continue to occur at the present age of nine years.

The occurrence of this disease in a father and son is considered to be of sufficient interest to warrant reporting.—*D. R. Bernhardt, M.D.*

Thompson, Walter A. L., and Ralston, Edgar L. Pseudarthrosis following spine fusion. *J. Bone & Joint Surg.*, April, 1949, *31A*, 400–405.

The results of a study of all spine fusion operations performed during a ten year period are reported. The study showed that of the 1,090 patients followed at least one year from the time of spine fusion, the incidence of pseudarthrosis was 16.6 per cent. The diagnosis of pseudarthrosis can be made, in most cases, after careful clinical and roentgenographic evaluation. Localized pain and tenderness, and the progression of deformity or disease, when present, aided in the establishment of the diagnosis. Study of lateral roentgenograms of the fusion area, with the patient first in the flexed and then in the extended position, was especially useful. In certain cases the diagnosis of pseudarthrosis could not be made until the fusion had been explored surgically.

The Hibbs technique of spine fusion was followed in all cases. Lumbosacral fusion and lumbosacral fusion with internal fixation were performed on 520 patients of the series. The remaining number was divided between operations for scoliosis, tuberculosis, spondylolisthesis and a miscellaneous group, which consisted of fusion for old fracture, localized osteoarthritis at other than the lumbar level, and wedging round back. The authors believe that the benefits of the operation of spine fusion for any disease or deformity of the spine cannot be determined except in patients in whom a successful fusion has been obtained.—*R. S. Bromer, M.D.*

Norley, Theodore, and Bickel, William H. Calcification of the bursae of the knee. *J. Bone & Joint Surg.* April, 1949, *31A*, 417–420.

Calcification may occur in any of the bursae about the knee and may cause disability and symptoms. Eight patients complained of progressive pain on motion, of swelling and of limited motion. Physical examination usually revealed a tender swelling over the involved bursa. Calcification within the bursa was not usually suspected until its presence was revealed in the roentgenogram.

The more important bursae about the knee are: (1) the prepatellar bursa, located anterior to the lower half of the patella; (2) the infrapatellar bursa located between the tibia and the lower portion of the patellar ligament; (3) the superficial pretibial bursa, located over the insertion of the patellar ligament; (4) variable bursae situated below and above the collateral ligaments; and (5) numerous and variable popliteal bursae. Chief of the popliteal bursae is the gastrocnemius semimembranosus bursa. Microscopic examination of the two bursae removed surgically showed extensive deposits of amorphous calcium and inflammatory reaction within the bursal tissues. The exact mechanism of the production of heterotopic calcification is not known. It has been suggested that in any mesenchymatous tissue of low metabolism, decreased circulation results in pathological calcification, especially in the presence of fibrosis of trauma or infection. Fibroblasts plus an excess of calcium plus an adequate blood supply result in bone.—*R. S. Bromer, M.D.*

Leonard, Morton H. Injuries of the lateral ligaments of the ankle; a clinical and experimental study. *J. Bone & Joint Surg.*, April, 1949, *31A*, 373–377.

Spontaneously reduced subluxations of the ankle often masquerade as sprains. Leonard states they are frequently undertreated by local procaine infiltration and adhesive strapping, with prolonged temporary and occasionally permanent disability for the patient. On the other hand, he believes that the plaster immobilization which these injuries require is often prolonged unduly. He performed a series of cadaver experiments to clarify the relative importance of the lateral ligaments in maintaining ankle stability and for better visualization of the mechanism of inversion injuries to these ligaments.

By observing the course of the lateral ligaments and the effect on ankle stability by cutting them in various combinations, he concludes that:

A. The anterior talofibular ligament is the important component of the fibular collateral ligament of the ankle.

B. Inversion films in severe ankle "sprains" should be taken with the foot in equinus, unless there is tenderness posterior to the fibula (which indicates injury to the posterior talofibular ligament). In this event the foot should be inverted with the ankle at 90 degrees.

Twenty-three patients of the 51 cases in his series studied were shown roentgenographically to have had spontaneously reduced subluxations. In all instances, both ankles were examined in inversion following general or local anesthesia, and a difference in the degree of parallelism between the articular surface of the talus and of the tibia on the two sides was considered diagnositc of a spontaneously reduced subluxation of the ankle. Unstable ankles should be immobilized in walking plaster for about six weeks and should then be strapped with elastoplast for an additional two or three weeks.—*R. S. Bromer, M.D.*

Steven, G. D., and Forestier, J. Discussion on diagnostic radiology in rheumatic disease. *Proc. Roy. Soc. Med.*, London, May, 1949, *42*, 354–364.

G. D. Steven:

Rheumatoid arthritis: Osteoporosis is of prime importance in the diagnosis of rheumatoid arthritis as it is the first roentgen change. Areas of greater radiolucency superimposed upon a generalized osteoporosis are seen in the more vascular areas in well established cases. In late chronic or quiescent stages there is a return of more normal distribution of densities. If no other signs are detected this stage may be mistaken for senile osteoporosis. Destruction of articular cartilage is of uniform nature, chiefly multiple small joint involvement. The articular margins show loss of normal sharp density. This change is best seen in the metacarpal heads, especially the second. Frank erosions may be seen. Pseudocystic changes and subluxation complete the roentgen picture.

Osteoarthritis: Loss of articular cartilage is the main change. This is seen best in the large

weight-bearing joints. Cartilage loss is usually uneven with greatest loss at site of greatest strain. Osteophytic formation, sclerosis, and pseudocystic formation complete the roentgen picture. Heberden's nodes are a common finding.

Gout: The punched-out lesions typical of gout and the secondary osteoarthritic changes which appear late in gout are described in detail as to appearance and pathogenesis.

Ankylosing spondylitis: The sacroiliac joints usually show the initial involvement. This involvement is bilateral. Spread of the disease is usually centrifugal with spread up the spine and later to other joints of the pelvis and lower limbs. Subarticular sclerosis with adjacent osteoporosis is characteristic. Gradual ossification of the capsular ligaments results in the typical "bamboo" spine.

Jacques Forestier:

The advantages of a complete study of the spine are discussed. The examination should include anteroposterior, lateral and oblique views.

Focal spinal changes, such as thinning of the disc with lipping of the adjacent vertebral angles, are usually associated with symptoms. Diffuse changes, such as osteophytic changes which occur in elderly people, usually are symptomless.

The classification of arthritic changes of the hip joint as adopted by the Second International Conference of Rheumatic Disease, 1948, is given.

A technique for the evaluation of function of the hip joint, while weight bearing, is detailed. —*D. R. Bernhardt, M.D.*

Linten, P. Types of displacement in fractures of the femoral neck and observations on impaction of fractures. *J. Bone & Joint Surg.*, May, 1949, *31B*, 184–189.

In the author's summary he states that various fractures of the femoral neck represent different stages of one and the same displacing movement. The displacement first produces an "abduction fracture" and terminates in an "adduction fracture," passing through the stage of an "intermediary fracture" which is less well recognized. These three types of fracture occur in response to the same injury and they differ only in the degree of displacement. He thinks it is a mistake to believe that in "adduction fractures" the femoral head lies medially to the collum. It lies posteriorly. Impaction is no more than the first stage of displacement of fractures in which there is limited displacement with contact still maintained between the fragments. An "impacted fracture" is not necessarily stable—if there is additional strain it may progress to the next stage of a displaced and unstable fracture. He mentions the overlap of shadows in roentgenograms. It is often assumed that such overlap indicates impaction but this this is probably untrue. In general, he believes that such an appearance indicates no more than close contact between the fragments with limited breaking of bone tissue in one region, so that there is exact correspondence between displacement and compression. There is much to be said in favor of the assumption that impaction, in the sense of interlocking of the fragments does not exist.

Linten also believes that the principles he enunciates apply not only to fractures of the femoral neck but to all other fractures at the ends of long bones. It is quite conceivable that valgus or varus relationships of the fragments may be attributable much more to the violence of the injury and the degree of resistance of the skeleton, than to the direction of the force of injury.—*R. S. Bromer, M.D.*

Dommisse, G. F., and Fainsinger, M. H. Vertical fracture of the patella. *Brit. J. Radiol.*, Nov., 1948, *21*, 571–574.

The authors present a rare case in which bilateral vertical fractures of the patellae occurred as the result of an indirect violence. This case was examined roentgenographically two and a half years later, and shows bony union of the fractures.

The differential diagnosis of this condition from that of congenital bipartite patella and traumatic separation of the bipartite patella is discussed.—*K. L. Krabbenhoft, M.D.*

Dawson, George R. Intra-uterine fractures of the tibia and fibula. *J. Bone & Joint Surg.*, April, 1949, *31A*, 406–408.

A case of intrauterine fractures of the tibia and fibula is reported. The patient was a white male baby. The roentgen examination made, three days after delivery, showed a faint fracture line and considerable thickening at the junction of the lower and middle thirds of the tibia. Extreme posterior bowing was present

in the lateral view, and slight medial bowing was shown in the anteroposterior view. The roentgen examination made five years after treatment showed the posterior bowing was corrected and medial bowing of 12 degrees was still present. At the age of five and a half years, the patient's left leg had a normal appearance.

Intrauterine fracture can occur in several ways. The first cause suggested was trauma during pregnancy with indirect injury to the fetus. Anatomic snaring off is another possibility. Diseases of the fetus to be considered in intrauterine fracture are: (1) osteogenesis imperfecta, (2) chondrodystrophies, and (3) syphilis. There have been many reports of pathological intrauterine fracture. A roentgenogram taken the first day or two after birth, showing either healing of normal bone or evidence of some bone lesion, would rule out an obstetrical fracture.

The criteria for intrauterine fracture of normal bone are roentgenograms showing absence of disease and normal repair of a fractured bone. These exposures should be made soon after birth since callus forms so quickly in the newborn that roentgenograms taken even a week after delivery would not rule out a birth fracture.—*R. S. Bromer M.D.*

Ehrenhaft, J. L., and Tidrick, R. T. Intramedullary bone fixation in pathologic fractures. *Surg., Gynec. & Obst.*, April, 1949, *88*, 519–527.

The authors have reported 10 cases of pathologic fracture of the femur treated by fixation with an intramedualllry nail. Of the fractures reported, 4 were due to Paget's disease, 5 to metastatic carcinoma, and 1 to multiple myeloma. There is no evidence from this small series that dissemination of the tumor was hastened in the patients with metastatic carcinoma or that the terminal course of the disease was unfavorably influenced. In the 4 cases of Paget's disease, a solid union occurred within a period of approximately four months.

In each instance immediate relief of pain at the fracture site was striking. No patient required external immobilization. All patients were placed upon a Boehler frame for a few days to effect elevation and temporary immobilization of the extremity. In no instance was the postoperative course complicated by wound infection, shock, hemorrhage or fat embolism. The average period of hospitalization following introduction of the nail was only two weeks. Because of slight bending of the tubular type nail in two instances the authors have abandoned the use of this type and have substituted the solid diamond-shaped "Hansen-Street" nail for femoral fractures.

In the author's experience, healing is facilitated by this method not only under the abnormal conditions of pathologic fracture but is aided also in other fractures where unusual conditions are present. These include those imposed by the patient's poor general condition or by unfavorable local conditions such as long standing non-union with sclerosis of the medullary cavity. A number of such fractures have healed when ordinarily one would not have anticipated such a result. Where non-union has occurred, the intramedullary nail in conjunction with on-lay bone grafts have been used. Healing has been early and function of the extremity satisfactory.—*Mary Frances Vastine, M.D.*

Kirshbaum, Jack D. Fibrosarcoma of the tibia following chronic osteomyelitis; report of a case. *J. Bone & Joint Surg.*, April, 1949, *31A*, 413–416.

Although carcinoma may develop in a sinus tract at the site of chronic osteomyelitis, sarcoma complicating this condition is extremely rare. Kirshbaum reports the case of a physician, male, aged sixty-six, who developed a growth in the left lower leg three months before admission to the hospital. He had had at the age of twenty-five, hematogenous osteomyelitis of the left tibia in the lower third. Ten years later the bone was curetted. An ulcer had developed at the site of a sinus, thirty-five years before admission, and had persisted in spite of local medication. The pathological report of a biopsy specimen was fibrosarcoma. The diagnosis of fibrosarcoma was subsequently confirmed by studies of the neoplasm removed from the amputated extremity. The patient was followed for three years, and no evidence of metastasis was found in that time.

The tumor in this case probably had its origin in the fibrous bone marrow of the tibia. The occurrence of this sarcoma supports the theory of chronic inflammation as a predisposing factor in the formation of malignant neoplasms.—*R. S. Bromer M.D.*

Willis, R. A. The pathology of osteoclastoma or giant-cell tumour of bone. *J. Bone & Joint Surg.*, May, 1949, *31B*, 236–240.

Willis first discusses in this paper the diverse and confusing terminology of giant-cell tumor of bone. The term "osteoclastoma" was first used in Great Britain by Stewart in 1922 and was later adopted by most British pathologists. He believes that there is now little room for doubt that this expresses correctly the histogenesis of the tumor. The close similarity between the tumor giant cells and the larger osteoclasts of bone-resorptive lesions, the identity of appearance of the tumor tissue with that of the masses of mingled fibroblastic and osteoclastic tissue in hyperparathyroidism (often wrongly called osteoclastomata for this very reason), and the conspicuous bone-resorptive effect of the tumors, together afford conclusive evidence of the osteoclastic nature of the tumor cells. He regards it as clear that osteoblasts and osteoclasts are but functional variants of cells of the same type. Since osteoblasts and osteoclasts are no more than reversed functional phases of cells of one kind, they might all be conveniently called "bone-formative cells." An osteoclastoma is a tumor of these cells in which the functional bias is osteoclastic rather than osteoblastic.

The age, sex and site incidence are next discussed. Willis agrees with most writers on age and sex incidence. He does not believe, however, that the giant-cell tumor is predominantly a tumor involving the epiphysis. This idea, he states, which has arisen for no other reason than that the tumors show a striking predilection for the ends of long bones, is incorrect. An osteoclastoma in a young bone with an epiphysis that is not yet fused is situated not in the epiphysis but in the metaphysis; the epiphyseal line is intact.

In regard to the structure of the osteoclastomata, young healthy tumors are uniformly red, brown, or sometimes pale and are usually soft and friable. Older tumors are altered by fibrosis, cyst formation, hemorrhage, pigmentation, yellow necrosis or calcification. A prevalent opinion that the roentgenographic appearances, and especially the multilocular or "soap bubble" appearances, of osteoclastomata are distinctive, is erroneous. Similar appearances can be produced by other expanding non-osteogenic tumors.

The microscopical features of healthy parts of the tumor are characteristic. The admixture of fusiform or rounded cells and multinucleated giant cells, and the absence of any signs of osteoid or bony differentiation, is unlike that of any other bone tumor. Mitotic figures may be found in small numbers in the mononucleated cells, but they are seldom found in the giant cells. The nuclei of the giant cells are identical with those of the mononucleated cells and there are appearances that suggest that giant cells are formed by the fusion of the mononucleated cells. The vascularity varies greatly. Secondary changes are often conspicuous, including hemorrhages, cysts, areas of pigmentation or fibrosis, and accumulations of lipoid-laden foam cells.

In most osteoclastomas, with characteristic clinical and histopathological findings, the tumors pursue a benign course, grow slowly, do not transgress the periosteum, do not metastasize and are curable by local removal. Osteoclastomata, like most other groups of tumors, show a range of structure and behavior, and a few, not initially distinguishable from their benign fellows, invade and metastasize. This malignant behavior does not presuppose any essential change of growth but is a property, ab initio, of certain members of the class. In some malignant cases reported, the structure of the metastases did not depart greatly from that of tumors of benign behavior.

Chondromatous osteoclastomata are rare tumors which resemble ordinary osteoclastomas in the rate of growth, and the roentgenographic appearance, but when cut the tissue is found to be partly or wholly cartilaginous. Microscopically they show areas of giant-cell tissue, identical in appearance with osteoclastomas, but mixed more or less intimately with cartilaginous tissue and with transitions between the two. Willis believes that the cartilage cells and the cells of the osteoclastomatous areas are the same, differing only in the presence or absence of a cartilaginous matrix and concludes that the proliferating chondroblasts and osteoclasts are related and mutually interconvertible. He believes, too, that a cartilaginous variant of genuine osteoclastoma does exist.

In the discussion of lesions resembling osteoclastomata, masses of tissue with a close structural resemblance to the usual osteoclastoma are found in generalized osteitis fibrosa (hyperparathyroidism) and less commonly in localized osteitis fibrosa. Such masses are not true tumors even when they attain large size. They

have no power of independent growth and they disappear when the bone reforms. "Myeloid" epulides should not be grouped indiscriminately with osteoclastomata because, again, resemblance does not denote identity. In many epulides the giant-cell tissue is clearly no more than inflammatory granulation tissue. Giant-cell tumors of synovial tissues also should be distinguished from osteoclastomata.—*R. S. Bromer, M.D.*

Prosser, T. M. Treatment of giant-cell tumours of bone with a review of twenty-five cases. *J. Bone & Joint Surg.*, May, 1949, *31B*, 241–251.

In this paper, 25 cases of giant-cell tumor treated at Westminster Hospital, London, are reported. The paper contains a well tabulated chart giving details of the histories, biopsies, etc., in concise form. In addition a short case history of each patient is given, with a discussion of the clinical features of the cases. Prosser states the diagnosis can often be made on clinical and roentgenographic grounds alone but biopsy is sometimes necessary and seldom, if ever, is contraindicated.

Some cases, he thinks, may best be treated by excision, but in general irradiation is the treatment of choice. In his series both gamma rays from teleradium and high voltage roentgen rays were used. Two opposing skin ports were used and the dosage delivered to the tumor in one course seldom exceeded 2,500 r. The average duration of treatment was four weeks and the total tumor dose recommended is 2,000 r except in the case of children where the tumor dose should not exceed 1,200 r. A second similar treatment was given after six months, and when necessary, a third, after eighteen months. In the first course a daily skin dose of 200 r and a tumor dose of 90 r were given. In cases treated by teleradium a 4 gram unit was employed with two opposing 63–64 sq. cm. skin ports; 245 r was delivered every forty-eight hours, each port being used on alternate days, for twenty days. Thus the total dose with teleradium was 2,450 r.—*R. S. Bromer, M.D.*

Windeyer, B. W., and Woodyatt, P. B. Osteoclastoma; a study of thirty-eight cases. *J. & Bone Joint Surg.*, May, 1949, *31B* 252–267.

Thirty-eight cases of osteoclastoma are reported in this paper. Twenty-five occurred at the end of a long bone. Nineteen were in the lower limb and half of these were near the knee joint. Six were in the upper limb and, of the remainder, 9 occurred in the vertebrae or the sacrum. More cases occurred in females than males. Just over half the cases occurred in the second and third decades. In 7 there was a definite history of injury preceding symptoms by several months.

Brailsford (1943) stated that roentgen examination, together with the history and clinical features, was sufficient to establish the diagnosis and that biopsy was not only unnecessary but even harmful and misleading. The authors believe that histopathological information is usually necessary before a certain diagnosis can be made, and that a limited biopsy is safe and reliable. Incisional biopsy was used in most cases.

Malignant change with the development of metastases occurs in a small proportion of cases, regardless of the particular treatment that has been employed. The methods of treatment employed by the authors included curettage or local excision, with or without irradiation, and irradiation alone. The patients treated by curettage or excision were dealt with during an earlier period than those treated by irradiation alone, and an exact comparison of results was not possible. The follow-up of their patients treated by radiotherapy alone has been too short to exclude possible recurrence, but the immediate results appear to show definite improvement upon those of surgical treatment.

From the study of this limited series, Windeyer and Woodyatt believe that malignant change occurred in a higher proportion of cases treated by curettage and radiotherapy than in those treated by radiotherapy alone.

It appears, the authors conclude, that in the treatment of osteoclastomata of bone, radiotherapy alone is the treatment of choice.—*R. S. Bromer, M.D.*

Ellis, Frank. Treatment of osteoclastoma by radiation. *J. Bone & Joint Surg.*, May, 1949, *31B*, 268–280.

Ellis first considers the problem of diagnosis of osteoclastoma. He states the diagnosis should be established beyond reasonable doubt before treatment is begun. He believes that biopsy is so valuable a method of diagnosis that it should always be used when the nature of a bone tumor is doubtful. The arguments advanced against

biopsy appear to have little validity. Moreover, he thinks, there is evidence that irradiation before or after biopsy has protective value. He has had some recourse to drill biopsy, which often provides unequivocal results and has certain advantages over open biopsy in that complications are less frequent and admission to the hospital is unnecessary. The differentiation of osteoclastoma from bone cysts is given in detail.

The aims of treatment, whether by curretage, resection, amputation or irradiation, are to relieve symptoms and restore normal bone structure and function of bone. Curettage may be unsatisfactory by reason of persisting mechanical weakness and the danger of local recurrence necessitating further operation. Resection is justified only when the site of the lesion permits complete removal without impairment of function. Amputation is seldom justified because the lesion is essentially local and satisfactory results can be obtained by conservative treatment. Irradiation is capable of achieving results no less satisfactory than those of surgical operation and without the danger of weakening the bone by removal of intact cortex in order to expose the tumor.

The irradiation used in most cases of Ellis' series was by roentgen rays, a total of 3,000 r being given on alternate days over a period of three weeks. A few patients were treated by implantation of radium into the cavity after curettage. The use of radium may cause bone necrosis and increases the risk of other complications. In all his cases, response to irradiation was good. Brief summaries of individual case histories are given in the paper. Four of the 26 cases were classified as healing lesions at the time of treatment though in each of them the history of this was short. Five of the 26 cases were excluded from the report because there was some doubt of the diagnosis. All others were true osteoclastomata, except one case which was a malignant osteoclastoma.

In only 2 of the cases treated was there apparent deterioration, shown in roentgenograms during the first eight to twelve weeks after treatment and later followed by recalcification during the next two or three years. Ellis feels that apparent extension of growth does not always occur after irradiation and that, if it does, it should not be the signal for ill advised surgery. It has been suggested that irradiation may cause malignant transformation of an osteoclastoma. It appears more probable, however, that when this is suspected the tumor has been malignant from the start. In regard to the effect of irradiation on epiphyseal growth, Ellis' view is that the possibility of such a complication makes it unwise to treat a simple bone cyst by irradiation in a child less than two years of age but that in true osteoclastoma, irradiation is justified even in early childhood. At present there is no clear evidence that irradiation in the dosage usually employed gives rise to significant growth change in the human being, and in Ellis' wide personal experience of treatment by irradiation he has had no case so affected.—*R. S. Bromer, M.D.*

Russell, Dorothy S. Malignant osteoclastoma and the association of malignant osteoclastoma with Paget's osteitis deformans. *J. Bone & Joint Surg.*, May, 1949, *31B*, 281–290.

Two cases of malignant osteoclastoma are reported followed by 3 cases of malignant osteoclastomata in Paget's osteitis deformans. The case reports are given in detail with illustrations of the histopathological sections. In the discussion which follows, the author describes two different types of evolution of growth of the metastasizing tumors, granted that the first two are accepted as authentic examples of metastasizing osteoclastoma. A frankly malignant change may take place in the stroma cells of the primary tumor with the production of cytological appearances that are difficult to distinguish from those of osteogenic sarcoma. Alternatively, the tumor may proceed to metastasis without appreciable morphological changes in its cells. Further experience alone can decide whether these two types of metastasizing osteoclastomata are to be distinguished. If such a distinction is confirmed, it follows that no accurate prognosis can be based on the histopathological appearances of a solitary osteoclastoma even though, by ordinary criteria, it may appear benign. The conspicuous amount of coarse-fibered bone in the subcutaneous metastases of one of her cases, appears to her, to establish the osteogenic capacity of the tumor cells. This point she considers of fundamental importance in that it links osteoclastoma and osteogenic sarcoma more closely than has been conceded, and explains many of the difficulties of interpretation of malignant varieties of osteoclastoma.

The association of malignant osteoclastoma with osteitis deformans, as reported in the last

3 cases the author believes, casts an interesting side-light on the disputed question as to whether or not a distinction should be drawn between the osteoclastomata that may be associated with generalized osteitis fibrosa and the solitary osteoclastomata that occur without general bone disease. Malignant tumors of bone complicate osteitis deformans in a small percentage of cases. These tumors are usually said to be osteogenic sarcomata. Such a diagnosis Russell thinks, may possibly be correct for the fifth case of her series, but she believes on histopathological grounds that malignant osteoclastoma is the true interpretation of the third and fourth cases.—*R. S. Bromer M.D.*

Fairbank, H. A. Thomas. Chondro-osteodystrophy, Morquio-Brailsford type. *J. Bone & Joint Surg.*, May, 1949, *31B*, 291–301.

Chondro-osteo-dystrophy is characterized by dwarfism with shallowness of the vertebral bodies, marked kyphosis, sometimes angular increase of the spinal curve at the dorsilumbar junction, and progressive changes in the femoral head and acetabulum in a child of normal intelligence. To a varying extent the whole skeleton is affected with the exception of the bones of the skull and face which are usually normal.

Hereditary influences are seldom apparent, whereas familial influences are common. Age, sex incidence, clinical characteristic and the etiology are discussed. The roentgenographic changes in 4 cases are reproduced to illustrate the usual changes found in the skeleton and are described in the text in detail. A special point is made of the appearance of the vertebrae at the lumbosacral junction where the upper and lower surfaces of the affected body are irregular and defective, with a tendency to approximate towards each other in front, thus accounting for a wedge-shaped appearance which is accentuated by a central prolongation or "tongue." Later on, multiple centers appear by which the defects are repaired and the epiphyseal rings are formed. The pathology is unknown. In the differential diagnosis, achondroplasia, gargoylism, dysplasia epiphysialis multiplex and cretinism must be differentiated. One clinical photograph and sixteen roentgenograms are included.—*R. S. Bromer, M.D.*

Fairbank, H. A. Thomas. Gargoylism. *J. Bone & Joint Surg.*, May, 1949, *31B*, 302–308.

The gargoylism type of osteo-chondro-dystrophy is characterized not only by dwarfism but also by a heavy, ugly facies, corneal opacities, mental deficiency, kyphosis, distention of the abdomen and enlargement of the liver and spleen. The author mentions the various theories of the etiology of the condition and describes in more detail the clinical signs and the roentgenographic appearance of the skeleton. In the spine, the upper and lower surfaces of the vertebral bodies are convex as shown in the roentgenogram so that they present a circular rather than a quadrilateral outline. The discs are biconcave and are deeper than normal. It is often said that the bodies are flat and spread, as in Morquio-Brailsford's type but this is not accurate. When there is angular kyphosis, one body is usually smaller than the others and is displaced backwards as if squeezed out of line. This deformity is seen in both types of chondro-osteo-dystrophy but there is no other resemblance. The displaced vertebral body is concave on its anterior surface, the upper part being deficient and the lower projecting forwards in the form of a beak. This beak is quite different, both in shape and position, from the central "tongue" seen in the Morquio-Brailsford type. The typical shape and displacement is seen most often in the second lumbar vertebra, and next in frequency in the first lumbar body. In only one case was the twelfth dorsal as well as the first lumbar vertebra small, beaked and displaced. A similarly peculiar shape is often seen in the vertebral body next below the one displaced and occasionally in the one above it. Angular kyphosis may be present without any vertebral body being small or displaced.

The progress of the condition, the pathology and differential diagnosis are also discussed. Two clinical photographs and eleven roentgenograms of the skeleton are included.—*R. S. Bromer, M.D.*

Copeland, M. M., and Geschickter, C. F. Chondroblastic tumors of bone; benign and malignant. *Ann. Surg.*, May, 1949, *129*, 724–735.

The authors review the subject of chondroblastic tumors of bone and present 25 cases of chondroblastoma which have been divided into benign and malignant by histopathological study. This has been supported by five year follow-ups. The distinctive clinical features of

chondroblastic tumors are: (1) age incidence of ten to twenty-four years, (2) localization predominantly in ends of long bones, (3) the average duration of symptoms in patients under twenty years of age is five months. Typical roentgenological finding is an area of rarefaction in the cancellous bone extending on either side of the epiphyseal line with an associated overlying periosteal reaction. As differentiated from giant cell tumors, these tumors do not expand beneath the shell of cortical nor do they have coarse trabeculae. The distinction between benign and malignant chondroblastomas cannot be made on the roentgenogram. The authors believe that in most cases the microscopic examination will permit classification as to whether benign or malignant. Resection or amputation should not be performed unless the lesion is verified as malignant. They advise biopsy followed by roentgen therapy as the initial procedure in all cases. Benign tumors do well following curettage or curettage with deep roentgen therapy.—*T. D. Allison, M.D.*

Miller, Leo Frederick, and O'Neill, Colman J. Myositis ossificans in paraplegics. *J. Bone & Joint Surg.*, April, 1949, *31A*, 283–294.

The authors in this paper have compiled data concerning the occurrence of myositis ossificans in paraplegics, as well as material which they have culled from the literature. They accept the classification of Noble: (1) myositis ossificans progressiva; (2) myositis ossificans circumscripta resulting from local trauma; (3) myositis ossificans without history of trauma.

The sites most frequently found involved were the hips, the upper thirds of the thighs and the knees. Hip motion was usually limited. The pelvis and lower extremities in some cases showed marked osteoporosis and with severe spasms, the hip was dislocated or the femoral neck was fractured. Urinary calculi were often seen. In fact, myositis ossificans was frequently an incidental finding on a "scout film" for kidney calculi.

The authors' studies on blood calcium, phosphorus, and phosphatase showed nothing of significance. The hip joints, in the roentgenograms of their patients, appeared fairly normal, but they were sometimes obscured by the calcification which was dense and trabeculated. The calcification most commonly extended anteriorly from the anterior superior iliac spine over the hip joint along the rectus femoris; either in addition to this course, or as an alternative, it sometimes descended medially from the iliopubic rami into the adductor group of muscles. There were a variable number of spurs, bands, or dense bridges of calcification from the trochanteric region of the femur to the acetabulum ilium or ischium.

The pathological changes are discussed in detail, likewise the theories of formation.—*R. S. Bromer, M.D.*

Lehman, William, and Kraissl, Cornelius. Glomus tumor within bone. *Surgery*. Jan., 1949, *25*, 118–121.

The authors reported 2 cases of intraosseous glomus tumor. Each lesion was in a terminal phalanx. This type of tumor was not suspected by the roentgenologists although they were not aware of the clinical data. The first patient complained of intermittent sharp pain which extended upward into the arm when the finger was struck. There was always a small tender area with slight soft tissue swelling at the distal phalanx. A small cystic area of diminished density in the base of the distal phalanx was demonstrated on the roentgenograms. The second patient had such a lesion in the base of the distal phalanx of a thumb. The typical lancinating pain extending into the arm was obtained by slight pressure over the lesion. This patient had had some roentgen therapy without benefit. The technical factors were unknown. Examination of the pathologic material from both cases showed glomus tumor tissue. Each patient became free of symptoms following curettement.

In 26 of 52 cases in which a glomus tumor was diagnosed in the Surgical Pathology Laboratory at the College of Physicians and Surgeons, the tumor involved the fingers. Fifteen of these lesions were subungual. The remaining tumors involved the eyelid, arms, elbows, forearms, wrist, knee, thigh, ankle and wall of the stomach. Thus almost half of the glomus tumors occur in regions other than in the fingers and toes.—*C. B. Holman, M.D.*

Andersen, Kjeld, and Therkelsen, Frederick. On fractures of the carpal bones, especially of the scaphoid. *Acta radiol.*, 1949, *31*, 343–357.

The material in this paper comprises 119 cases of intra-articular fractures of the scaphoid

and 27 fractures of the other carpal bones. One hundred fractures of the scaphoid were followed with a view to the functional result and 98 with a view to the roentgenological result. The average follow-up period was 8.4 years. This study revealed the paramount importance of immobilizing the fracture immediately after the accident. In cases of delayed union drilling by the method of Beck had a favorable effect in 4 of 8 whereas 2 cases of established non-union remained unchanged.

It was found that when there was established non-union when the fracture was diagnosed—in 29 of these cases—union did not result even from prolonged immobilization.

In the united cases the functional result was ideal in 29, good in 12, and poor in 4. As to the non-unions the result was ideal in 6, good in 22, and poor in 14. In the 18 operated cases the results corresponded to those obtained in the ununited ones.

A total of 27 cases of fractures of other carpal bones, comprising chip fractures of the semilunar, pisiform, and cuneiform, exhibited union in all cases examined roentgenologically. In all but 2 cases the functional results were excellent. Some of the patients were treated with immobilization for a few weeks—others received no treatment.—*Mary Frances Vastine M.D.*

Abramson, Daniel J., and Kamberg, Samuel. Spondylitis, pathological ossification and calcification associated with spinal-cord injury. *J. Bone & Joint Surg.*, April, 1949, *31A*, 275–283.

The bones, ligaments and soft tissues and also joints may be affected by permanent injury and damage to the spinal cord. Neuropathic joints have been early commented on. Calcifications and ossifications in the soft tissues, chiefly about the hips, have been noted, likewise erosive bone changes about the trochanters. In this paper, the authors emphasize another change, a spondylitis similar in many respects to the rheumatoid type, with frequent involvement of the diarthrodial joints.

Thirty-five cases of injury to the spinal cord were studied. The roentgenographic bone changes and the level of the injury to the cord were correlated and were divided into two groups: Group A included lesions below the first lumbar vertebra and all partial lesions, irrespective of site, since the roentgenographic findings in these two types revealed little essential difference; Group B included all complete transverse lesions above the first lumbar segment.

In Group A, the findings were not significant. In Group B, osteoporosis of the pelvis occurred, with marked sclerotic changes in 3 cases, and a combination of the two in 5 patients. In all but 3 of the cases of this group, some degree of sclerosis was present in the sacroiliac joints, varying from partial to complete fusion. Other findings noted were sclerosis about the acetabular margins, lacy periostitis of both ischia, a narrowed symphysis pubis, and streaky calcification in the buttocks. In the lumbar spine, the apophyseal joints showed a varying degree of fusion. In some patients, there was osteoporosis of the bodies, in others sclerosis, or a combination of the two. In only 2 patients was calcification of the paraspinal ligaments noted. Proliferative bone changes and soft tissue calcifications were found about the hip joints and the upper portion of the femur. There was no definite period time of between the trauma and the roentgenographic manifestations, although most of the patients were seen one to two years after injury.

From a pathological standpoint, the authors believe, explanations offered by previous writers seem reasonable. These are based on the importance of circulatory disturbance. Hyperemia of bone is followed by decalcification; diminished circulation, by osteosclerosis; and loss of blood supply, by necrosis. Pathological calcification can occur in any mesencyhmal tissue of low metabolism when vascularity is further reduced by trauma and infection. Bone may form in any region where there are fibroblasts, an excess of calcium, and an adequate blood supply. Adult tissue which can be differentiated into primitive mesenchyma may be rebuilt as bone with an excess of calcium.

The subjective complaints and objective findings, in relation to the abnormalities found in the skeleton, were not striking because of the involvement of the spinal cord.—*R. S. Bromer, M.D.*

Zürcher, P. Die Posttetanische Kyphose. (Posttetanic kyphosis.) *Ann. paediat.*, Jan., 1948, *170*, 32–53.

According to various reports in the literature, a high percentage of patients with tetanus will develop spinal deformity (20 to 84 per cent). These changes are believed to be the result of

compression fractures causing flattening of one, two, or more vertebral bodies. Not infrequently a wedging of the vertebral bodies occurs to a varying degree. The disc spaces are usually well preserved and paraspinal soft tissue masses are absent. The deformity of the vertebral bodies frequently results in the development of round, or angular kyphosis and bulging of the anterior segment of the thorax (pigeon chest). The compression fractures are almost exclusively confined to the dorsal spine and affect in 70 per cent of all cases the 5th and 6th dorsal vertebrae. The pathogenesis and differential diagnosis of the observed spinal changes are discussed in detail. The case of a six year old patient with tetanus, who developed posttetanic spinal deformity, is described.—*H. S. Weens, M.D.*

Mellbye, Ake H. Supplementary remarks to article on Schüller-Christian's disease (printed in *Acta radiol.*, 1948, *30*, 279). *Acta radiol.*, 1949, *32*, 71–72.

The author's attention has been drawn to the great similarity between his Case 1 published in 1948 and several of the cases of neurofibromatosis Recklinghausen recorded by Rosendal in *Acta radiologica*, 1938, *19*, 273. Therefore, the author has brought his case up for re-perusal.

In Mellbye's patient there is no anomalous pigmentation over the swelling in the right temporal region. However, there are bone changes on this side. In addition, there is destruction in the contralateral maxilla. In his patient there is destruction involving the base of the skull with the greatest degree of involvement in the middle fossa and the orbital base. There is also enlargementof the sella. Such extensive destruction is conceivable in Recklinghausen's disease, though unusual. All the other destructions observed are consistent with neurofibromatosis. Naturally the decisive factor must be whether the histopathological examination supports this diagnosis. L. Kreyberg has expressed the opinion that this case may be a neurofibroma or a neurinoma with slow growth and with remnants of lipoid macrophages. According to this the diagnosis neurofibromatosis Recklinghausen must be considered probable.—*Mary Frances Vastine, M.D.*

Dimson, S. B. Albers-Schönberg disease. *Proc. Roy. Soc. Med.*, London, Feb., 1949, *42* 77–80.

A single case of Albers-Schönberg disease in a six and a half month old infant is presented in detail including family and patient histories, physical examination and laboratory data.

Roentgenograms showed generalized increase in density of the entire skeleton typical of this disease. In the skull, the base and parietal region were chiefly affected. Posterior clinoids were clubbed and the sella turcica narrowed. There was no distinction between cortex and diploe. The clavicles, vertebral bodies and pelvis were uniformly dense. Though ends of long bones showed clubbing and a greater increase in density, no transverse bands were seen. Centers of ossiffication were normal. There were changes suggestive of active rickets. Metacarpals, metatarsals and phalanges of the four extremities showed ring-like shadows of increased density at the ends.

A brief commentary on the incidence, etiology and pathogenesis of the disease concludes the article.—*D. R. Bernhardt, M.D.*

Knutsson, Folke. The myelogram following operation for herniated disc. *Acta radiol.*, 1949, *32*, 60–65.

The myelographic diagnosis of herniated disc is based on the pressure effect made by the prolapse on the contrast filled dural sac. The operative procedure in herniated disc consists of incision of the prolapse and extirpation of the detached fragments of the degenerated disc substance. After termination of the operation the surgeon can establish the disappearance of the protrusion of the disc substance. At subsequent myelography the indentation into the dural sac should accordingly have disappeared.

Not in all cases, however, does the myelogram subsequent to operation regain an entirely normal appearance. A total extirpation of the herniated disc may be difficult to accomplish owing to adhesions or other complicating factors. The operation may be complicated by hemorrhage leading to cicatrization and adhesions. At subsequent myelography there may, in such cases, be a deformation of the dural sac which is due entirely to postoperative deformity. In such cases it is difficult or impossible to determine whether the deformity is due to adhesions or whether there has occurred another disc protrusion.

The author has had 3 cases in which this postoperative defect was present but in which, at

operation, no herniated disc was found. The impression on the dural sac in these 3 instances was due to cicatrization.—*Mary Frances Vastine, M.D.*

Hywel-Davies, P. I. Tuberculous disease of the spine simulating malignancy in a male patient, age 30. *Proc. Roy. Soc. Med.*, London, Feb., 1949, *42*, 90–91.

The diagnosis of tuberculosis of the spine was made on a patient who presented the clinical findings of local tenderness and bilateral psoas spasm, and a roentgen picture suggesting tuberculous disease. The patient did not remain completely in bed and became progressively worse. Roentgenograms five weeks later showed such rapid destruction of the diseased vertebrae that malignancy was considered. The patient had neurological symptoms referable to the vertebral destruction.

The pain diminished with absolute bed rest. The patient also showed a flaccid paralysis which is not commonly seen in metastatic involvement. Tuberculosis was therefore considered the most probable diagnosis, and the marked destruction of the vertebrae attributed to the patient's remaining ambulatory in the early stages of the disease. Roentgenograms approximately nine months subsequent to the first examination revealed much new bone formation.—*D. R. Bernhardt, M.D.*

Feuchtwanger, J. L., Multiple tuberculous lesions of the spine. *Brit. J. Radiol.*, Aug., 1948, *21*, 400–405.

The difficulty in differentiating the various types of infective spondylitis is emphasized. It is further stressed that tuberculous lesions of bone are not entirely destructive as has been generally thought. The lesions of bone production and sclerosis seen in secondary infections may also be seen in tuberculosis in varying degrees.

Pathologically, tuberculosis of the spine is primarily osteolytic. Intervertebral spaces may be preserved in the presence of extensive destruction of the vertebral bodies or may be narrowed due to extrusion of the nucleus pulposus into the softened bone or ligamentous tissue. Tuberculous infections rarely involve the posterior arches, or transverse processes. Tuberculosis of the spine spreads by the extension of abscesses under the anterior longitudinal ligament and/or hematogenous spread. Pressure on the cord with paralytic symptoms and gibbus formation is common. Bone tuberculosis may be destructive (exudative, caseous) or productive (sclerotic) in type. The classical picture of Pott's disease is that of the exudative type. The characteristic features of pyogenic infections are compared to those of tuberculosis. The stages and factors participating in tuberculous healing and repair are discussed.

The roentgen appearances of tuberculous spondylitis are discussed. The comparison of the roentgen appearance of the pathological specimen with that obtained in situ is encouraged.—*K. L. Krabbenhoft, M.D.*

Bosworth, David M., and Levine, Jack. Tuberculosis of the spine; analysis of cases treated surgically. *J. Bone & Joint Surg.*, April, 1949, *31A*, 267–274.

This study is based upon 177 consecutive cases of Pott's disease treated surgically during the six year period from 1940 to 1945 inclusive. Its primary purpose was to examine the factors affecting the hospital mortality rate in this condition. They conclude that in tuberculosis of the neural arch the prognosis is poor, but fusion is often successful. While negroes appear more susceptible to tuberculosis of the spine than white patients they have an equal chance for recovery when offered adequate surgery and care. Children with Pott's disease progressed unfavorably under conservative care, but presented the greatest and most rapid recovery rate in their whole series when fusion was done. Pulmonary tuberculosis, when controlled by modern methods, does not appear to affect the prognosis of patients operated upon. Amyloid disease accompanying tuberculosis of the spine is practically always fatal. Positive proof of amyloidosis was found in 15.2 per cent of their patients (27 patients). All but one died, a mortality rate of 96.3 per cent.—*R. S. Bromer, M.D.*

Isaacson, Alvin S., and Whitehouse, Walter M. Spontaneous sacro-iliac obliteration in patients with tuberculosis. *J. Bone & Joint Surg.*, April, 1949, *31A*, 306–311.

The authors state that it is now recognized that the poor prognosis previously ascribed to tuberculosis of the sacroiliac joint was the result of the associated widespread dissemination of the tubercle bacillus, rather than to the local disease process. The consensus in this country is that, in order to obtain bony ankylosis of the

joint, operative intervention is necessary. They have recently observed, as an incidental finding in several patients coming for treatment of tuberculosis of the spine or hip joint, that one of the sacroiliac joints had been obliterated by bony trabeculations. If these lesions represent the end result in patients with sacroiliac tuberculosis who have not been operated upon, they lead one to question the advisability of bone-graft procedures for osseous fixation of the joint.

The films of approximately 330 patients were reviewed. Twenty-two patients were found with destructive and obliterative lesions, either alone or in combination, of one sacroiliac joint. To this group they added another case, not cared for at their institution. Seventeen (74 per cent) eventually had partial or complete obliteration of one sacroiliac joint by bony ankylosis. In 15 of these patients, bacteriological proof of tuberculosis elsewhere in the body was obtained.

It was impossible to make any definite conclusion as to the cause of the obliteration in the sacroiliac joints. Their presumptive evidence, however, is that the lesions are of tuberculous origin. Should their interpretation of their findings be correct, their feeling is that a program based on approximately one year of conservative therapy should be instituted before operative fusion is contemplated. Should the sacroiliac joint appear at the end of that time to be approaching what might be termed "fibrous ankylosis," bone-graft surgery could then be performed. It is their impression that these joints which are obliterated by bone have a better chance of maintaining permanent arrest of their tuberculosis.—*R. S. Bromer, M.D.*

Badgley, Carl E. Etiology of congenital dislocation of the hip. *J. Bone & Joint Surg.*, April, 1949, *31A*, 341–356.

In this discussion of the etiology of congenital dislocation of the hip, Badgley believes it logical to conclude that the etiology of congenital dislocation of the hip is a developmental fault of the hip system produced by extrinsic factors—growth circumstances—with a combination of hereditary and environmental faults which alter the normal growth potential or the intrinsic mosaic pattern. Congenital dislocation and congenital dysplasia are developmental deformities produced by secondary adaptive faults. Inherited characteristics and environmental factors may alter the intrinsic mosaic pattern by a faulty timing in development.

His concept of congenital dysplasia of the hip and congenital dislocation is that, through a developmental fault, the acetabulum has failed to deepen and the head and neck have become anteverted. The anteversion tends to turn the head forward, displacing the cartilaginous sphere laterally, so that the glenoidal labrum and acetabulum cover less of the head than usual. The poor adaptation of the head and acetabulum continues dynamically to require altered growth changes, altering the intrinsic mosaic pattern. These growth changes are manifested in subluxation or acetabular dysplasia by pushing upward of the glenoidal labrum, widening of the socket, and enlargement of the head. If the head escapes completely past the edge of the glenoidal labrum, a true dislocation results. The glenoidal labrum, unobstructed returns by its elasticity to its proper position, lying between the head and the acetabulum. The head of the dislocated hip no longer has stimulus for overgrowth seen in the subluxation, so that it remains small and round, although becoming flattened on the side if in contact with the ilium.

Heredity can play an important part in altering growth and time factors. Badgley thinks that the known embryological development of the hip joint is certainly opposed to the theory of a primary inherited failure of development of a portion of the acetabulum.—*R. S. Bromer, M.D.*

BLOOD AND LYMPH SYSTEM

Laake, Helge. Myelomatosis; examination of clinical material. *Acta med. Scandinav.*, Feb., 1949, *132*, 440–457.

Seventeen cases of multiple myelomas are reported. Pains in the back and in the extremities were the dominating initial symptoms.

In all the patients, except one, there was found hypochromic anemia of varying degree. In all cases the number of white blood cells was normal, while thrombocytopenia was noted in one patient. Proteinuria was present in all the patients, and with one exception they all had Bence-Jones proteins in the urine. A glomerular lesion with reduced filtration was observed in four-fifths of the patients and tubular insufficiency was found in about three-fourths of those examined. Autopsy findings seem to sup-

port the assumption that the glomerular changes form the primary factor in the genesis of the myeloma kidney.

Average time of survival was 1.8 years. The cause of death was cachexia in the great majority of cases.—*Charles Nice, M.D.*

Smith, R. G., and Campbell, D. A. Some technical considerations in the arteriographic examination of the lower extremity. *Surgery*, Oct., 1948, *24*, 655–661.

The authors summarized the more important technical aspects of their method of arteriographic examination based on a series of more than 100 arteriograms. Diodrast in 35, 50, or 70 per cent concentration was used. Patients were tested for unusual sensitivity and no reactions were noted.

The aims of this type of examination are (1) to reveal certain facts relative to the extent, type and location of pathologic lesions and (2) to be easily performed. Certain explanatory features are considered such as: (1) the necessity of injecting the radiopaque medium into a patent major artery at the point where it enters the extremity; (2) injection of the radiopaque material in the most proximal part of the extremity; (3) need for sufficient concentration of medium for good visualization; (4) occlusion of femoral artery by digital compression above site of injection to slow the flow; (5) need for two complete roentgenograms with a short time interval between exposures to avoid errors in interpretation; (6) anesthetization of skin and arterial wall; (7) unimportance of special ability to introduce the needle into the femoral artery; (8) consideration of exposure of the examiner to radiation; and (9) use of a special cassette tunnel to facilitate the rapid change of the position of the cassettes. This special cassette permits exposure of half of each of two 14 by 17 inch films longitudinally, with subsequent shift of the cassettes and exposure of the other halves of the films.

Thirty cubic centimeters of diodrast is used, the first exposure being made after 25 cc. has been injected rapidly while the artery is occluded above the site of injection by digital pressure. The cassettes are then moved to the second position and the pressure released for four seconds during which time the remaining 5 cc. is injected. The second exposure is then made. Exposure factors are a distance of 6 feet, 68 kv., 300 ma. and 1/20 second.—*C. B. Holman, M.D.*

GENERAL

McMenemey, William H., and Vickers, Anthony A. Cysticercosis. *Brit. J. Radiol.*, Feb., 1949, *22*, 84–87.

Cysticercosis is infestation of man by the larval or bladder worm stage of *Taenia solium*, the pork tapeworm. The adult tapeworm in the gastrointestinal tract of man, or the pig, liberates ova which, when ingested, usually by the pig but sometimes by man, develop into onchospheres which penetrate the intestinal mucosa, and are transported by the blood stream. In the soft tissues they become enveloped in a fibrous tissue capsule and, if not ingested, die and become calcified. The walling-off process is well developed by three or four months, and the larvae live between three and six years. It then takes three years or more for calcification to develop. In the brain they are round, and in muscle tissue they are deformed by pressure into a somewhat oval or fusiform shape with the long axis parallel to the surrounding muscle bundles. The calcifications vary from 1 to 5 mm. in diameter and are up to 1.8 cm. in length. When seen axially they may be circular and 1 mm. in diameter. In the muscle the larvae calcify irregularly with a central area of decreased density. In the brain, on the other hand, the calcification is dense at one point in the cyst and there is almost imperceptible calcification in the rest of the cyst. The largest calcification seen in one patient's brain was 2 mm.

Since the lesions in the brain may cause increased intracranial pressure or epilepsy and since the calcifications are so small, a study of the skull might not suffice to exclude cysticercosis as the cause.—*E. F. Lang, M.D.*

ROENTGEN AND RADIUM THERAPY

Mains, M. Paul. Anti-histamine ointments for skin protection in radiation therapy. *Radiology*, April, 1949, *52*, 579–581.

The author reports his experience with 5 per cent benadryl or pyribenzamine in an aquaphor base. Patients were instructed to apply the ointment to all areas receiving treatment immediately after irradiation and again at bedtime. Oral administration of 25 mg. of benadryl preceded each meal. In well over 100 cases, the author feels that objectively the patients showed a markedly increased skin tolerance to radiation. The antihistamine drug

is believed to have increased the skin tolerance. The following résumé concerns 1 of the 3 cases reported in some detail. After roentgen therapy following a radical breast amputation, a severe skin reaction with blistering and peeling was experienced. In the same patient, at a later date after a similar dose to the opposite breast area but with the use of antihistamine drugs both orally and locally, the patient showed no appreciable erythema over any of the treated areas.—*C. N. Borman, M.D.*

Shorvan, L. M. A further survey of radiation sickness with particular reference to its treatment by pyridoxine. *Brit J. Radiol.*, Jan., 1949, *22*, 49–55.

Sixty-nine individuals, treated by roentgen irradiation for malignant or degenerative disease of various organs, were given pyridoxine for subsequent radiation sickness. In 63.8 per cent the subjective results were graded as excellent, in 26.1 per cent as good, and in 10.1 per cent the treatment failed to give relief. The irradiation was carried out with the usual factors for intermediate and deep therapy. Daily doses of radiation varied from 30 r to 720 r with an average of approximately 500 r. At the onset of symptoms following the therapy, five 10 milligram tablets daily by the oral route were usually administered, but twice that dosage was often required. Intravenous injection of 50 milligrams twice per week was employed in severe cases. At no time was the drug administered prophylactically, since the number of patients developing radiation sickness were definitely in the minority in comparison to those exhibiting no ill effects from radiation treatment. In addition to the obvious subjective relief, the author also noted that the leukocyte count was often increased following the pyridoxine therapy, after an initial depression secondary to the irradiation.—*Harold Fulton, M.D.*

Jarvis, J. L., and Cayer, David. Effects of radiation therapy on the urinary excretion of niacin and riboflavin in patients with malignant diseases; relationship to radiation sickness. *Radiology*, April, 1949, *52*, 574–578.

Varying concepts of the etiology of radiation sickness are briefly reviewed. In an effort to demonstrate whether or not malnutrition predisposes to radiation sickness, the authors measured the urinary excretion of niacin and riboflavin in a group of patients with malignant disease, before and after roentgen therapy. Thirty patients, all hospitalized, and receiving typical courses of deep therapy were studied. Urinary excretion levels were measured before therapy was begun and at the end of one week of therapy, with further observations up to a period of one year. The excretion levels were unchanged throughout the study and were unaffected by roentgen or radium therapy. The constancy of the urinary levels in this series suggests that the degree of tissue destruction resulting from roentgen or radium therapy is is not sufficient to release stores of niacin. Previous studies have shown that patients who are showing marked evidence of tissue destruction, often have abnormally high excretion levels of niacin. The urinary levels were not of the magnitude noted in patients with any considerable degree of parenchymatous liver disease; this finding would seem to indicate that radiation sickness is not due primarily to a disturbance of the liver's ability to metabolize these vitamins. In those patients who had nausea and vomiting, the mean excretion levels of niacin and riboflavin were significantly reduced, but were not changed after roentgen therapy.—*C. N. Borman, M.D.*

Clarkson, J. R., and Herbert, R. J. T. Surface and emergent doses in radiotherapy. *Brit. J. Radiol.*, Oct., 1948, *21*, 494–500.

When exit doses are obtained from commonly employed isodose curves and the part irradiated is of limited thickness, the figures are almost always too large. The authors have calculated exit doses from known depth doses, basing their calculations on the assumption that the total forward-moving scatter is equal to the backward-moving scatter beginning a few centimeters beyond the skin surface. Measurements on a water phantom and on a few patients have sustantiated their calculations. They show that the percentage dose at the exit surface is equal to one-half of the sum of the percentage depth dose at that distance from the irradiated surface, including back scatter, plus the depth dose of the primary beam measured without back scatter.— *E. F. Lang, M.D.*

Hultberg, Sven, Short-distance low-voltage roentgen therapy of inflammatory conditions in the tonsils. *Acta radiol.*, 1949, *32*, 66–70.

The favorable results of short distance low voltage roentgen therapy are reported in 10 cases of chronic tonsillitis treated during the

years 1943–1948. The author suggests that the method be more widely used. Two or three doses are given. Each treatment consists of 500 r delivered with 50 kv. and 2 ma. at a focal-skin distance of 4 cm. No additional filter is used. Each treatment is given in ten seconds and is technically easy to perform.—*Mary Frances Vastine, M.D.*

Sylven, Bengt. Malignant melanoma of the skin; report of 341 cases treated during the years 1929–1943. *Acta radiol.*, 1949, *32*, 33–59.

Out of 341 patients with cutaneous malignant melanomas 291 verified cases (85.3 per cent) were admitted to treatment at the Radiumhemmet during a fifteen year period from 1929 through 1943. Because of the close follow-up service, complete records brought up to December, 1948, were available for analysis. In spite of its limitations, clinical staging with reference to the extent of disease at admission is considered of prime importance for the evaluation of results. Present treatment methods characterized by conservative surgical interventions partly in combination with radiation treatment have in this material provided the following uncorrected cure rates: net five year cure rate (conventional), 34.6 percent; end result at 1948 in determinate group, 30.8 per cent; over-all end result at 1948, 23.7 per cent.

The author expresses the opinion that more patients would probably be salvaged by wider and earlier surgical intervention and, in particular, by prophylactic gland dissection in Stage I patients.—*Mary Frances Vastine, M.D.*

Stetson, Charles G., and Schulz, Milford D. Carcinoma of the eyelid. *New England J. Med.*, Nov. 10, 1949, *241*, 725–732.

The authors review 301 patients with previously untreated primary carcinoma of the eyelid seen in the Massachusetts General and Collis P. Huntington Hospitals during the twelve years from 1933 through 1944. Cancer of the lid constituted 2.5 per cent of skin cancer in these institutions. The lesion is slowly growing, average recognized duration being $3\frac{1}{3}$ years. The median age is fifty-eight, with peak incidence falling in the sixth decade. If correction is made for normal population decay, the incidence of cancer of the eyelid is found to increase in linear fashion after the age of forty. The lesion was in the lower lid in almost half the cases, with the inner canthus representing the next most common site. Less common sites were the upper lid and outer canthus. Fifty-four per cent of the lesions were confirmed by biopsy; 82 per cent of these were basal cell carcinoma, 14.5 per cent squamous cell carcinoma, 2.4 per cent mixed basal cell and squamous cell, and 1.2 per cent adenoid cystic epitheliomas.

Seventy-six per cent were treated by irradiation, and 24 per cent by surgical excision or electrosurgery. Most of the irradiated lesions were treated with a single large dose, usually with 200 kv. filtered radiation, but some with 100 kv. Effective tumor dose was about 3,000 r. When radon was applied topically, the average skin dose was about 3,275 gamma roentgens. No significant difference was noted in the number of failures of the various modes of treatment. Failures from initial treatment occurred in 13 per cent, and resulted from inadequate irradiation, inadequate excision, and in 11 cases from radioresistance. The anatomical site of the lesion had no bearing on percentage of failures, provided the disease had not already become uncontrollable through extension to lymph nodes, orbits, or sinuses. However, failure of primary treatment was twice as frequent in squamous cell as in basal cell lesions. Of the 29 failures from primary treatment, 86 per cent were manifest as primary failures within three years; all but 5 of the 29 were subsequently controlled by re-treatment. Net failures comprised 2.5 per cent of the entire series.

Complications of surgical treatment were uncommon, consisting of unsightly scar, tissue defect requiring plastic revision, or lid-drop. Stenosis of the tear duct occurred in 26 per cent of patients in whom the inner canthus was irradiated. This complication is often unavoidable, especially when the tumor has already invaded the duct. Such lesions do not lend themselves to surgical intervention, and a certain number of stenosed ducts are to be expected. The eyeball was routinely shielded by a molded lead plaque between the eyelid and the globe, and no radiation cataract was observed.

The authors recommend roentgen studies of the sinuses and orbit in search of bone involvement in all lesions showing fixation, infiltration of the inner canthus, or invasion of the orbital contents. They believe that in most primary carcinomas of the eyelid roentgen therapy is the method of choice, since the appearance of

failures and other undesirable results is no greater than with other forms of therapy, the discomfort to the patient is small, and cosmetic and functional results are at least as good as those obtained by other means. For small lesions, they suggest daily doses of 1,200 to 1,500 r (air) of 100 kv. unfiltered radiation at a skin-target distance of 20 cm., given to a total of 3,600 to 4,500 r (air). For infiltrating and fixed lesions, 140 kv. to 200 kv. roentgen rays filtered by 0.25 or 0.50 mm. copper and 1 mm. aluminum are suggested.—*Henry P. Brean, M.D.*

Poppe, Erik. Osteogenic sarcoma—along what lines should it be treated? *Acta radiol.*, 1949, *31*, 335–342.

The author concludes that the results of treatment of osteogenic sarcoma by amputation at the earliest possible moment, as recommended in the Scandinavian literature, are not good. It is possible that preoperative irradiation or local operation (resection) before amputation will yield more favorable results. He believes that all cases of bone sarcoma in his country should be admitted to one or two hospitals for only in this way is it possible to gain greater experience in the treatment of these tumors. No serious objections from hospitals thus excluded from treating these tumors will be made as the surgery of these conditions presents problems of comparatively minor interest.

Summary. In 1942, Eker and Poppe published a report from the Norwegian Radium Hospital including a series of 22 cases of osteogenic sarcoma. All the patients treated primarily by operation (either amputation or disarticulation) died within three years following the operation.

In a group of 20 cases of osteogenic sarcoma from the University Hospital of Oslo, 14 cases were treated radically by amputation. One of these patients is still alive and symptom-free ten years after operation. The remaining 13 patients are dead. In many of these cases it was remarkable how soon after operation lung metastases were demonstrable roentgenologically.

One patient treated by irradiation in the hope of effecting a cure is living ten years after treatment. There has been no recurrence. This patient has an irradiation necrosis of the femur with considerable shortening of the thigh.

The diagnosis of osteogenic sarcoma is often difficult and may remain uncertain for a long time. This is another factor which speaks against early amputation.—*Mary Frances Vastine, M.D.*

Price, C. H. G. Observations upon the lymphopenia of x-ray irradiation. *Brit. J. Radiol.*, Oct., 1948, *21*, 481–493.

Sixteen patients with normal blood counts were subjected to roentgen treatment, and concomitant and subsequent blood studies were made. The patients were all treated through two anterior and one posterior field to the ovarian region with a total tumor dose of between 2,800 and 3,500 roentgens. Time intervals were maintained at a constant as much as possible. The courses of treatment varied between fifteen and thirty days in duration.

Throughout the treatments the lymphocyte counts showed a steady decrease. The decrease was most rapid in the first fourteen days, but subsequently the rate of change decreased rapidly until the alteration in daily counts was low. It was felt that the demonstration of two different rates of response to irradiation indicated that there were two factors acting on the lymphoid structures: one was the direct effect; the other an indirect one, such as liberation of material from the adrenal which supresses lymphopoiesis, or destruction of some substance necessary for development of lymphocytes.

The clinical tolerance to irradiation was assessed by noting the degree of headache, malaise, diarrhea, and vomiting. There was no correlation between the clinical assessment of tolerance to irradiation and age, rate of change of lymphocyte count, initial or final lymphocyte count, the integral dose, or the rate of dosage.—*E. F. Lang, M.D.*

Jones, Arthur. Clinical reactions and injuries in supervoltage therapy. *Proc. Roy. Soc. Med.*, London, Oct., 1948, *41*, 703–709.

The following observations have been made at St. Bartholomew's Hospital in London.

The skin dosage for a second degree erythema is 4,000–5,000 r fractionated over three to five weeks with 1,000 kv. therapy. Skin reactions develop more slowly, reach a maximum later, and take longer to subside with 1,000 kv. than with 200 kv.

In the "deep therapy" range of roentgen rays the factor limiting radical treatment is often the severity of the skin reaction, but the

penetrating properties of the 1,000 kv. beam may produce a deep mucositis in the tumor region thereby limiting the amount of radiation permissible. This is best seen in the mouth, pharynx and larynx and in the pelvis. Mucosal reactions are the major burden with which patients have to bear in supervoltage therapy.

Comparative data between 1,000 kv. and 200 kv. are given to support the conclusion that considering the extent of the lesion and total tumor dose given general reactions are less frequent and less severe in the supervoltage range.

It has been found that supervoltage therapy has a definite advantage over "deep therapy" in the treatment of localized mediastinal masses in certain cases of reticulosis in that an adequate lesion dose can be delivered before severe blood changes supervene.

The fact that relatively few injuries have occurred at St. Bartholomew's is attributed to careful planning and treatment of each individual case. Each case of injury is described in detail.—*D. R. Bernhardt, M.D.*

Innes, G. S. The million volt x-ray plant. *Proc. Roy. Soc. Med.*, London, Oct., 1948, *41*, 691–703.

A history of the installation of a 1,000 kv. roentgen-ray plant at St. Bartholomew's Hospital, London, in 1936 and its subsequent modifications and performance is given.

Originally it was intended to vary the wavelength of the roentgen rays to determine the relative lethal effect of such variation on normal and malignant tissue, other physical factors remaining constant. Because of the many variables necessarily introduced, such as change in depth dose, the original intent was found to be impractical. It was then decided to operate the tube under fixed optimal conditions. Between 1939 and 1948 the physical factors employed were: 1,000 kv.; 4.5 ma.; 100 cm. focus-skin distance; filter, 4.2 mm. Fe, 2 mm. Al, 2 mm. Pb, 2 mm. Al, half-value layer 9.3 mm. Cu; output 40 r per minute with B.S. for 10 by 10 cm. field.

The physical advantages of increased depth dose and the relative efficiency of small ports in 1,000 kv. therapy as compared with lower voltage therapy are given in some detail. The imposition of dense structures, such as vertebrae and the proximal femur, appreciably decrease the depth dose in 250 kv. therapy but have little effect in 1,000 kv. therapy. Similarly the level of ionization in the tissue adjacent to the bone is not appreciably increased as it is in intermediate voltage therapy. The 1,000 kv. beam causes relatively less ionization in the superficial tissues than the 250 kv. beam per quantity of radiation delivered.

Several isodose curves of 1,000 kv. therapy for body sections are given to illustrate the ease with which high doses can be delivered in depth to lesions without excessive exposure of superficial tissues. Further advantage of increased depth dose is the free selection of ports of entry. The beam can be directed so as to avoid vital and susceptible organs rather than to achieve the most economical path to the lesion.

The article closes with techniques of therapy which capitalize on the advantages inherent in 1,000 kv. therapy.—*D. R. Bernhardt, M.D.*

Williams, I. G. The million-volt x-ray therapy. *Proc. Roy. Soc. Med.*, London, Oct., 1948, *41*, 709–718.

This report is an analysis of the results of treatment of malignant diseases by means of 1,000 kv. roentgen therapy at St. Bartholomew's Hospital, London. The policy at this hospital is to treat early malignant disease by surgical methods, if feasible. The patients referred for 1,000 kv. roentgen therapy were considered incurable by any other means. Seven hundred and twenty-six cases were available for study, and all cases are included in the statistics presented. Less than 5 per cent fell into the early operable group, but were treated by radiation for such reasons as refusal of surgery, patient's condition, etc.

Carcinoma of the breast: A dose of 4,500 r is delivered evenly to the chest wall, axilla, and supraclavicular region in four to five weeks. Of 56 patients treated there were no cases of pulmonary fibrosis, one developed clavicular necrosis and one developed pectoral muscle fibrosis. Eighteen per cent of those not previously treated elsewhere survived a minimum of three years. Details of treatment, results and survivals of each stage of disease are given. The observation is made that the disappearance of the primary tumor and regional lymphatic metastases are more certainly and more easily obtained with supervoltage than with "deep" therapy.

Carcinomas of the antrum, extrinsic and intrinsic larynx, tongue, esophagus, bronchus, urinary bladder, anal canal, rectum, and

cancers in various other sites are each discussed at length giving case histories, therapy given, survivals, and any other pertinent information in detail.

In conclusion, the author offers a table of comparison of two groups of patients treated at St. Bartholomew's. One group was treated with 1,000 kv. therapy and the other group with 200 kv. therapy. The survival rates show no marked difference with the exception of carcinomas of the breast, antrum, intrinsic larynx and the rectum. In these cases the 1,000 kv. group showed much higher survival rates than the 200 kv. group. In 1,000 kv. treatment of the bladder and anal canal survivals have been obtained in sites not previously treated by roentgen radiation. The survival figures are 32 per cent of 25 cases and 29 per cent of 23 cases respectively.—*D. R. Bernhardt, M.D.*

Finzi, N. S. The million-volt x-ray research at St. Bartholomew's Hospital. *Proc. Roy. Soc. Med.*, London, Oct., 1948, *41*, 719–720.

The object of the research was to determine if there were any advantages in the 1,000 kv. over 200 kv. machines already in use. It was hoped to use the higher voltage under as nearly similar conditions to the 200 kv. machines as possible, but the weight of the applicators was too great to make that practical. Thus the focal-skin distance had to be lengthened and a different method of localizing the rays by means of an adjustable diaphragm on the tube employed. A lighting system showed the exact field on the patient. From the beginning it was realized that no "staggering improvement" in results would occur.

The war interfered greatly because of alerts and bombings. Cases which did not fall within certain previously selected criteria had to be treated with 1,000 kv. and in many cases the machines had to be used for palliation only which was not originally planned. The fact that great palliation was obtained in many of the late cases is stressed by the author. The survival rates compare favorably with the lower voltage rates; however, the author states that in some type of cases the figures are not statistically valid.

Two case histories in which the lower voltage therapy failed and the million volt secured a successful result were cited. One was a carcinoma of the body of the uterus; the other was a carcinoma of the vocal chords.

The occurrence of necrosis was almost entirely in the first cases when treatment techniques were being investigated and large fields were used. Later multiple small fields were used with good results and few injuries.

The author states that those who have worked with 1,000 kv. therapy prefer it to the lower voltage. They consider the tumor dose delivered to be more accurate and believe they can achieve good results with less damage to normal tissue.

The author and his associates are interested in further work with even higher voltages. They would like to aim at a machine which would first work at 3 to 5 million volts and subsequently be put up to 20 million volts in an endeavor to ascertain the optimum biological voltage.—*D. R. Bernhardt, M.D.*

Fricke, Robert E., and McMillan, James T. Radium therapy in carcinoma of the female urethra. *Radiology*, April, 1949, *52*, 533–540.

The literature is reviewed and the anatomy well discussed. Thirty-five cases are classified as to age, symptoms, location, grade of malignancy and types of therapy. Five year survival of 44.1 per cent was obtained. The best method was a combination of surgery and radium therapy.—*E. C. Baker, M.D.*

Goldscheider, Gertrude. Effect of intrauterine radium therapy on ovarian function. *Lancet*, March 26, 1949, *1*, 521–523.

This study gives the results of radium treatment in 28 cases of menorrhagia whose hormone output was checked by the original Aschheim-Zondek technique. This was compared to eight cases who were given roentgen castration. Of the 28 cases, 27 were cured of the menorrhagia. In the remaining case hysterectomy was necessary. The dosage of radium in this series was 600 to 1,900 milligram element hours. Women of child bearing age were usually given smaller doses and in menopausal cases, the usual dose was about 1,100 mg. el. hr. The sterilization dose used with radiation therapy was a dose of 600 r to the skin over each of four areas, two anterior and two posterior, the treatment being spread over a period of twelve days. The factors were, 140 kv., 6 ma., 60 cm. focus-skin distance, filter 1 mm. copper plus 1 mm. aluminum.

The author concludes that the dose of intra-

uterine radium usually given at the Marie Curie Hospital for benign menorrhagia though capable of producing amenorrhea does not produce an artificial menopause except in women of menopausal age, where such small doses may influence their ovarian function. Roentgen irradiation of the ovaries does establish the menopause.—*J. S. Summers, M.D.*

Gilmour, M., Gluecksmann, A., and Spear, F. G. The influence of tumor histology, duration of symptoms and the age of the patient on the radiocurability of cervix tumors. *Brit. J. Radiol.*, Feb., 1949, *22*, 90–95.

Specimens from 1,125 patients with carcinoma of the cervix were graded histopathologically into three groups: anaplastic, squamous or differentiating, and columnar cell types. The patients were then grouped into four clinical stages, depending on the clinical extent. Patients in the same clinical stage then were analyzed to determine the factors associated with five year symptom free survival.

In the same clinical stage differentiating tumors give a better survival rate. There is a lower incidence of differentiating tumors in women under forty, and therefore the survival rate in older women is slightly greater. Clinical Stages I and II ("early" malignancies) occur in about the same proportion in all age groups.

No correlation was found between the duration of the symptoms and the radiocurability in any one clinical stage.—*E. F. Lang, M.D.*

De Wesselow, O. L. V., and De Wardener, H. F. Carcinoma of the parathyroid gland with hyperparathyroidism. *Lancet* May 14, 1949, *I*, 820–823.

Unequivocal malignant disease of the parathyroid gland with hyperfunction is rare though many clinically benign cases have been claimed as malignant solely on the microscopic appearance. The author found 3 cases of hyperfunction of the parathyroid showing undoubted evidence of clinical as well as histopathological malignancy in the literaure. The present paper records a fourth case.

This report is of interest in that deep roentgen therapy was used twice. The factors used during the therapy are not recorded, but it is noted that on each occasion there was some biochemical improvement although never a complete cure. The author says that this very moderate response is not surprising in view of the differentiated nature of the tumor. He also states that it is interesting to note the complete lack of response in 1 of the 3 cases in the literature. This was the case of Meyer. The author feels that in his case the complete resistence to roentgen therapy was probably due to the continued excessive production of hormone from the lung and kidney metastases which were not subjected to deep irradiation.—*J. S. Summers, M.D.*

Proctor, Donald, F., Polvogt, Leroy M., and Crowe, Samuel J. Irradiation of lymphoid tissue in disease of the upper respiratory tract. *Bull. Johns Hopkins Hosp.* Nov., 1948, *83*, 383–428.

The physiological function of the upper respiratory tract is to clean, humidify and warm the inspired air. Strategically placed in the nasopharynx are the adenoids, tonsils and islands of lymphoid tissue. This tissue contributes to the process of antibody formation, to production of macrophages, and furnishes proteid to the blood upon the dissolution of lymphocytes. The pathology of upper respiratory infection is concerned with this tissue. Upon hypertrophy following infections, crypts in tonsils and adenoids become deep, often denuded of epithelium lining, and accumulation of horny epithelium interferes with drainage. These crevices offer a good point of entrance, retention, and multiplication of the air borne virus and a cold results. This infection in turn activates the bacteria present and ear, sinus and bronchial complications may result. The bacterial invaders may be attacked with chemotherapy, but to prevent the virus infections the crypts and crevices in the lymphoid tissue should be removed by surgery and irradiation. This treatment is also effective for deafness due to obstruction of the eustachian tubes by adenoids. Examination was made of 1,365 children with hypertrophied lymphoid tissue. Those with impairment of hearing were irradiated while the remainder served as controls. Four years later 600 of these were re-examined and those irradiated cases with hearing impairment were much improved. Moreover the patients irradiated experienced fewer and milder colds than the non-irradiated control group. This latter finding was experienced before by otolaryngologists on surgical removal of tonsils and adenoids but often symptoms would re-

cur. An important point now, however is to check also the lateral nasopharyngeal walls, the choanae and the posterior part of the septum for cryptic lymphoid tissue. These areas are not accessible to surgical manipulations but are easily reached with irradiation. After irradiation the patients should be checked for recurrence of the tissue and treated again if hypertrophy recurs. Irradiation may be repeated two or three times without danger if proper dosage is used. The optimum dosage of irradiation is that which will stop mitosis and multiplication of cells rather than to destroy great amounts of the tissue. This will serve to keep the lymphoid tissue flat and free of crevices and still leave enough to carry on phyisological function. The beta-ray type of applicators are most suitable since beta rays are only superficially penetrating and about 93 per cent are absorbed by 1 cm. of tissue.

For the past twenty-four years applicators with several types of filters were used and half an erythema dose to buccal mucous membrane was given up to three times yearly. The present technique is to use an 0.3 mm. monel metal 50 mg. radium sulphate applicator. This has a large beta-ray output and has a radioactive length of 15 mm. One applicator is placed in each nostril so that the tip rests on the posterior pharyngeal wall and is left in for twenty minutes. This is repeated twice at two week intervals. The patient is examined for recurrence of tissue and irradiation may be repeated once or twice at yearly intervals if necessary. A series of patients was followed for over two and a half years and of 128 patients treated because of frequent colds, 40 per cent showed marked improvement. Of 282 patients treated for impaired hearing due to obstructed eustachian tubes, 85 per cent had great and lasting improvement.

A statistical study of 400 patients treated with irradiation and local chemotherapy at the Hagerstown Clinic is given. Eighty-three per cent of all patients seen because of hearing impairment had otitis or upper respiratory infection thought to account for the deafness. Before treatment 66 per cent had hearing impairment ranging from a 20 to 50 decibel loss, but following treatment only about 26 per cent remained in this group. Of 41 children with bronchial asthma treated, only 17 per cent showed no improvement after a follow-up of nearly three years. Other data are also given.

It may be concluded from the twenty-four years of experience with irradiation of the nasopharynx in upper respiratory infections that this treatment correctly applies is of much benefit and free of harmful effects.—*Jerome J. Wiesner, M.D.*

Dawson, E. K. Precancerous conditions of the breast. *Brit. J. Radiol.*, Dec., 1948, *21*, 590–594.

"Precancer" is defined as a condition or conditions of the breast which will eventually become malignant even when the carcinogenic agent is withdrawn. The precancerous lesions of the breast are usually clinically apparent as enlargement and nodularity with varying degrees of cyst formation, forming the hyperplastic breast. These hyperplastic breasts, most evident in the climacteric period, may contain areas of adenosis or epitheliosis. Adenosis produces large and numerous lobules. In the author's experience, adenosis does not precede carcinoma, but gradually fades out, with a residual fibrosis and hyalinization. The other type of hyperplasia, epitheliosis, is cellular proliferation of the epithelium of the ducts and smaller lobular structures. Only a minority of breasts which show epitheliosis microscopically become carcinomatous; in the majority, after a phase of intraductal proliferation, more or less prolonged, the cells degenerate, with or without cyst formation. A grossly cystic condition usually means a benign lesion and is dismissed as precancerous lesion. However, in the so-called fatty cysts in which the degenerating cells within form masses of foamy cells, malignant cell formation may occur. It is suggested by the author that all carcinomas of the breast are associated with the presence of such fatty material in mammary ducts, and its source is not necessarily restricted to epithelial cell degeneration.—*Harold Fulton, M.D.*

Scarff, R. W. Prognosis in carcinoma of the breast. *Brit. J. Radiol.*, Dec., 1948, *21*, 594–596.

A discussion of the histopathologic grading of breast carcinoma and its metastases in relation to prognosis is presented. It is stressed that although grading of the lesion is important, the clinical stage that the disease has reached is of much greater prognostic significance. In general, if the original tumor is of a low grade (Grade 1 of Broders), the prognosis is better than if the tumor were of a higher

grade (Grade 2 or 3). Likewise, metastases to regional lymph glands are more common in the higher grades of malignancy. There is a discrepancy, however, in that many cases of low grade and stage offer a poorer prognosis than cases of high degree of malignancy. There are several possible explanations: (1) In many tumors of organs other than the breast, a primary growth of low grade may have metastases of a higher grade which will form a new center for dissemination. It is obvious that cellular grading of the primary growth in these cases will be useless from a prognostic standpoint. In the breast, however, this is rare. In 91 of 110 cases the metastases were placed in the same histopathologic group, in 18 they appeared to be in a lower group and in only 1 case in a higher or more malignant group. (2) Handley and Thackray studied the internal mammary glands and have found that it is possible that these glands be invaded by tumor cells when axillary gland involvement is absent. Even when the internal mammary chain is examined there are other routes for dissemination of malignant cells; i.e., direct supraclavicular spread and spread by the blood stream. (3) In every malignant growth the rate of growth and liability to metastasis are unfortunately not always comparable. In the breast a rapidly growing and radiosensitive carcinoma may metastasize late and complete extirpation may be possible; whereas a scirrhous type of tumor growing slowly but invading early may defy eradication yet allow the patient to live for years after local invasion has taken place.

From the radiologic standpoint the author believes that accurate clinical staging is unsatisfactory but that histopathologic grading may be of considerable value.—*Harold Fulton, M.D.*

Cade, Stanford. Discussion on carcinoma of the breast. *Brit. J. Radiol.*, Dec., 1948, *21*, 596–599.

The stage of the disease and the type of treatment administered are the two interdependent factors in results and prognosis in breast carcinoma. A scheme of clinical staging of breast carcinoma is presented by the author:

Stage I—Tumor of the breast only.
Stage II—Tumor of the breast+skin changes and/or axillary glands.
Stage III—Tumor of the breast+supraclavicular glands or contralateral axillary glands or fixation to pectoral fascia.
Stage IV—Skeletal or visceral metastases.

Stages I and II can be treated by radical mastectomy, Stage III is beyond surgical excision and Stage IV suitable for irradiation or endocrine therapy of the palliative type only. Irradiation is of value: (1) as the only means of treatment in Stage III cases; (2) preoperatively in Stage II cases where it improves the results to be expected if radical mastectomy alone is performed; (3) postoperatively in Stage II cases beyond the area covered by the radical amputation: supraclavicular and anterior mediastinal glands and skin flaps.—*Harold Fulton, M.D.*

McWhirter, R. The value of simple mastectomy and radiotherapy in treatment of cancer of the breast. *Brit. J. Radiol.*, Dec., 1948, *21*, 599–610.

With modern standards of operability only approximately 56 per cent of the total cases of breast carcinoma referred to a large general hospital are suitable for radical mastectomy. The five year survival rate of the total number of cases is unlikely to exceed 25 per cent. Because of the failure of the radical operation in many cases, in 1941 the method of simple mastectomy and radiotherapy was begun at the Royal Infirmary of Edinburgh. Technical aspects of the operative procedure are listed and basically concern an attempt to prevent the spread of malignant cells by the procedure and to allow radiotherapy to begin as soon as possible after the operation (usually two weeks). Only one full course of therapy is given. Four fields are used and every field is treated every day. The axilla is covered by two opposed fields, the anterior extending to the supraclavicular region. The chest and anterior mediastinum are treated by tangential fields. A minimum tumor dose of 3,750 r in three weeks is given. A 250 kv. unit is employed and heavy filtration is recommended.

In 1941–1945 the five year survival rate of all cases (1,345) of carcinoma of the breast treated by this method was 43.7 per cent. In advanced cases without distant metastases the five year rate was 29 per cent. It is stressed that simple mastectomy and a low standard of radiotherapy will be associated with poorer results than those obtained by radical mastectomy alone.—*Harold Fulton, M.D.*

Gilmour, M. D., Tod, M. C., Charles, A. H., Martindale, L., and McLaren, H. C. Discussion on the artificial menopause, indications, technique and complications. *Proc. Roy. Soc. Med.*, London, May, 1949, *42*, 311–320.

Mary D. Gilmour:

Radium as a means of inducing an artificial menopause has its chief use in the treatment of excessive functional bleeding from the uterus, especially at the menopausal age.

A technique of castration is given: Intrauterine radium 50 mg. for twenty-two hours. This gives a dose of the order of 190 (gamma) roentgens to each ovary. This is adequate for most cases.

Menopausal symptoms following radium castration are the same as those of natural menopause. Whether or not uterine cancer is a complication of radium induced menopause is a moot question.

Margaret C. Tod:

Malignant disease should be excluded before roentgen irradiation castration. Surgery, if feasible, is more desirable than irradiation, if the aim is to prevent conception. The usually prescribed roentgen radiation dose does not guarantee sterility in a young woman. Usually one normal then one abbreviated period follows delivery of a castration dose.

Conditions for which artificial menopause was induced are: (1) menopausal menorrhagia and metropathia hemorrhagica, (2) fibroids, (3) endometriosis, (4) cardiac and other systemic diseases. Most failures to induce amenorrhea were in the first group. The author used 600 r delivered in two days or 450 r delivered to the ovaries (depth dose) in one exposure. The latter dose is considered adequate.

The advantages and disadvantages of roentgen irradiation castration are discussed.

A. H. Charles:

The induction of an artificial menopause by irradiation or surgery as regards indications, immediate and remote therapeutic results, and the occurrence of complications, their frequency and severity are discussed in detail.

One hundred thirty-seven patients of a total of 154 reported improved general health following radium induced menopause; 8 were unimproved, and 9 were worse. The majority of patients reported no menstrual flow following radium application. Fewer reported one or more periods. The immediate morbidity of 79 cases was 5.1 per cent. Those were due to pelvic cellulitis, radium burn of the cervix and vascular thrombosis. All cases were given 2,000 mg-hr. radium application with 0.5 mm. platinum and 1.2 mm. silver filtration.

The occurrence of uterine corpus carcinoma as related to the age of menstrual cessation, and the possibility of radium application in castration doses causing fundus carcinoma are discussed.

The relative merits of surgical and radiation treatment of fibromyomata and endometriosis are evaluated.

Miss L. Martindale:

A large series of women treated for metropathia hemorrhagica, fibrosis uteri, or fibromyomata of the uterus either by surgery or by irradiation is reported. Carefully selected cases treated by irradiation showed excellent results. The indications and technique of treatment are given.

H. C. McLaren:

Menopausal symptoms following radium-induced menopause are frequent and severe in this author's experience. The ease with which radium castration is achieved, however, make it a valuable procedure despite the above stated disadvantage.—*D. R. Bernhardt, M.D.*

Read, Charles D. The role of surgery in the treatment of carcinoma of the cervix. *Am. J. Obst. & Gynec.*, Dec., 1948, *56*, 1021–1036.

Read states that at his hospital (Chelsea Hospital for Women in London) the Wertheim operation has been done continuously in carefully selected cases. He believes that surgery has an important place in cervical carcinoma treatment, despite the tendency to favor radiotherapy.

Victor Bonney performed 500 Wertheim operations between 1907 and 1936; 63 per cent of all cases seen were so operated. This series included tumors of Stages I, II, and III. Regional lymph node metastases were found in 40 per cent of those operated upon. The operative mortality was 14 per cent, or 70 of the 500. In the gland free group the operative mortality was 10 per cent, and 20 per cent in the gland involved group.

The glands of 300 of these cases were microscopically free of malignancy. In the other 200, no invasion was seen. Fifty-three per cent, corrected to 58 per cent, was the five year cure rate in those cases not showing gland involvement. Twenty-two per cent, corrected to 23 per cent, was the five year cure rate in cases with involvement. Overall cure rate was 41 per cent. After taking into consideration the 37 per cent of patients seen but not operated upon, an absolute cure rate of 25 per cent, corrected to 26 percent, results.

Results obtained with radiotherapy are compared. Five workers, whose figures were reliable, reported a total of 2,583 patients treated up to 1926; 614 five year survivals were obtained. This gives a percentage of 23.8. The author states that the latest published results show an improvement.

In spite of either method of treatment, many patients die of the disease. The author asks the following quesions: "Can we salvage the lives of any of these patients who are destined to die even after adequate radiotherapy? In addition, is it ever desirable to employ surgical means without previous radiotherapy?"

Since 1936, at various hospitals and nursing homes, the author and his colleague, Frank Cook, working independently, have performed 207 Wertheim operations with a mortality rate of less than 3 per cent. The low mortality rate is attributed to careful selection of cases (14 per cent of presenting cases), improved anesthesia, the use of whole blood and plasma, the use of chemotherapy and antibiotics, and good nursing care. Selection of cases for radical surgery is now limited as follows:

1. Radioresistant growths.
2. Columnar cell cervical carcinoma.
3. Vaginal vault stenosis.
4. Complicating large fibroids or ovarian cysts.
5. Complicating salpingitis.
6. Patient refusal of radiotherapy.
7. Complicating pregnancy.

He has done radical surgery 62 times following previous irradiation. One of those cases is described as remaining positive by biopsy for cervical adenocarcinoma following the use of local radium and two full courses of deep roentgen therapy.

During 1936 to 1941, 54 Wertheim hysterectomies were done on cases which were not suitable for irradiation or had radioresistant lesions. Thirty-four of these were Stage I, and 20 Stage II lesions. The five year cure ratio was 44.4 per cent. The mortality rate was 5.5 per cent.

The regional lymph nodes are thought to be involved in 20 to 25 per cent of Stage I cases, 30 to 35 per cent of Stage II, 40 to 50 per cent of Stage III, and over 60 per cent in Stage IV cases.

The author states that the use of vaginal applicators of radium alone can never sterilize the node bearing areas. He also questions the ability of deep roentgen therapy to accomplish this.

Positive lymph nodes, unaffected by deep roentgen therapy in conjunction with a cured cervix after a full course of radium and roentgen treatment have been found by the author in performing lymphadenectomy. In 37 cases, or all those cases proving negative for involvement of nodes, the author cannot believe that they were ever involved. He states that he has never removed adherent nodes which had been sterilized by irradiation and were free of growth. He further states that neither he nor Bonney has seen successful radiation treatment to a recurrence following the Wertheim operation. He agrees with Taussig that lymphadenectomy has a place in selected Stage III cases showing local cure by radium, and believes that Stage II and selected Stage I cases should also be included.

The technique of the Wertheim operation is described.—*Mary Helen Cameron, M.D.*

RADIOISOTOPES

Bush, F. The integral dose received from a uniformly distributed radioactive isotope. *Brit. J. Radiol*, Feb., 1949, *22*, 96–105.

Calculations are presented demonstrating the integral doses for gamma radiation to cylinders, elliptical cylinders, cubes and cuboids using their areas, and the doses to spheres and spheroids using their volumes. The dimensions of an average patient are used and the total dose rate when the source is uniformly distributed calculated for individuals from 40 to 100 kilograms in weight, and from 140 to 200 centimeters in height. The dose is given in megagram roentgens per hour in tabular form.

In addition, the loss of energy due to beta particle emission at the surface of the body is calculated.—*E. F. Lang, M.D.*

Rawson, R. W., Skanse, B. N., *et al.* Radioactive iodine; its use in studying certain functions of normal and neoplastic thyroid tissues. *Cancer*, March, 1949, *2*, 279–292.

The authors' continued studies with radioactive iodine have led to valuable and enlightening information on the normal and morbid physiology of the thyroid gland.

In 1938, Hertz, Roberts and Evans showed that the thyroid is capable of concentrating labelled iodine to a far greater degree than other body tissues. It has also been shown that thyroids of animals rendered hyperplastic by the administration of thyroid-stimulating hormone have a greater uptake of iodine than do normal glands. The thyroid of hypophysectomized animals show a lesser degree of avidity for iodine than glands in the normal animal.

The thyroid of clinical Graves' disease with its hyperplasia and iodine deficiency demonstrates a markedly high uptake of radioactive iodine. The urinary excretion of iodine in untreated patients with Graves' disease is about one-third that excreted by euthyroid cases, and this fact has lent itself as a diagnostic measure in this disease.

The authors have applied the techniques used in studying normal and hyperfunctioning thyroids to investigate the functional capacity of benign and malignant tumors of the thyroid, by comparing the concentrating ability of tumor tissue with that of surrounding normal tissue. This study was conducted in 23 benign tumors and in 21 cancers of the thyroid. Tracer doses of I^{131} were administered one to seven days prior to thyroidectomy, following which sections of the excised gland and adjacent tissues were processed and their radioactivity measured for unit of tissue. Radioautograms were also made to supplement the study by localization of the iodine in the cellular pattern. The benign tumors are classified according to the degree of differentiation; malignant tumors were classified as papillary carcinoma, adenocarcinoma, epidermoid carcinoma and carcinoma simplex.

The following pertinent conclusions were reached:

1. Benign tumors of the thyroid show a lesser degree of affinity for iodine than does normal thyroid tissue.

2. The amount of uptake of iodine by benign tumors increases with the degree of histological differentiation.

3. Most malignant tumors of the thyroid have little or no avidity for iodine.

4. The uptake of iodine by metastases from thyroid cancers may be increased by removing or destroying the normal thyroid. The mechanism of the phenomenon is explained by two theories: (a) the normal thyroid by its presence, attracting iodine that would otherwise be taken up by tumor; (b) in the absence of normal thyroid, the tumor assumes the function of supplying thyroid hormone.

5. Thiouracil is unable to inhibit the uptake of iodine by functioning cancers of the thyroid to the same extent as seen in normal thyroid.—*W. C. Gallo, M.D.*

McCorkle, H. J., Low-Beer, B. V. A., Bell, G. H., and Stone, R. S. Clinical and laboratory studies on the uptake of radioactive phosphorus by lesions of the breast. *Surgery*, Aug., 1948, *24*, 409–415.

Eighty patients having various types of lesions of the breast were given tracer doses of 300 to 500 microcuries of radioactive phosphorus intravenously and the radioactivity over surfaces of the body was detected by a Geiger-Müller counter during a period of forty-eight hours after the administration. Clinical, pathologic and radiologic data were complete for 62 patients. Of 17 patients with benign lesions, 16 gave skin surface measurements comparable to those of normal skin. Radioactivity was markedly increased over 4 benign inflammatory lesions. All measurements made over the cellular types of primary malignant tumors exceeded by more than 25 per cent the measurements over normal skin. Radioactivity was markedly increased over ulcerated and infected neoplastic lesions, while over small malignant lesions, mucoid carcinoma and lesions located more than 0.5 cm. from the surface of the skin in obese breasts it was comparable with that over normal skin. Forty-one patients with malignant lesions were so examined. Of 2 patients who had had hormonal therapy, only 1 showed increased readings over the involved breast.

The article contains 8 interesting and self-explanatory drawings illustrating the method. —*C. B. Holman, M.D.*

Dudley, Robert A., and Dobyns, Brown M. The use of autoradiographs in the quantitative determination of radiation dosages from

Ca^{45} in bone. *Science*, April 1, 1949, *109*, 327–328.

Experimental method for determination of safe tracer dosage of Ca^{45} is described. Autoradiographs of bone with film exposed to known controls at same time are calibrated with a microphotometer. The known controls are percentages of the peak blood activity.—*E. C. Baker, M.D.*

MISCELLANEOUS

Evans, Robley D. Quantitative inferences concerning the genetic effects of radiation on human beings. *Science*, March 25, 1949, *109*, 299–304.

Experimental data on *Drosophila melanogaster* are presented. These show the spontaneous gene mutations and the radiation induced mutations as observed quantitatively. By means of mathematical formulae the above results are used to calculate the result of radiation on mutations in humans. It is concluded "that no detectable increase in abnormalities is likely to result, even after many generations, if a small fraction of the population receives daily radiation doses up to 0.1 roentgen per day."—*E. C. Baker, M.D.*

Olsson, Olle, and Löfgren, Olov. Hyaluronidase as a factor hastening the spread and absorption of water-soluble radiopaque substances deposited intracutaneously, subcutaneously or intramuscularly. *Acta radiol.*, March 31, 1949, *31*, 250–256.

It was found that the treatment of the injection site (usually the gluteal region) with a subcutaneous and intramuscular deposit of 2.5 TRU (turbidity reducing units) hyaluronidase ten minutes prior to the injection of the contrast medium facilitated the injection and hastened the spread and absorption of the radiopaque substance. The infiltration of the tissues was slight and very transient. The resistance offered to the injection was remarkably low. The injection was not followed by a sense of tension or tenderness over the injected area.

An illustration showing a urogram of an adult is included in the article. In this case the 2.5 TRU hyaluronidase had been injected ten minutes before 13 cc. of diodrast (35 per cent) diluted with 26 cc. sterile distilled water was injected (into the gluteal region). Three minutes after the injection, the dye was visualized in the renal pelves.

Summary. A roentgenological method is given for demonstrating and controlling the spreading and absorption-prompting effect of hyaluronidase in man. This enzyme is used to hasten the spread and absorption of water-soluble contrast media injected into the tissues. —*Mary Frances Vastine, M.D.*

Klumpar, Josef. Relation between the radiation dose tolerated by the skin and the distance of the radiant source from the skin. *Acta radiol.*, March 31, 1949, *31*, 223–232.

The surface dosage of gamma rays required to produce a certain degree of skin reaction by radium therapy depends on the distance between the radiophore and the surface of the skin. At a small focus skin distance as much as five times greater surface doses may be applied than at great distances.

On the basis of empirically determined application times it was demonstrated that the depth dose 4 mm. below the surface was responsible for the reaction of the skin. In all cases from a focus skin distance of 0.25 to 8.0 cm., the same degree of reaction was obtained if the dose 4 mm. below the surface was 3,500 plus 600 r.—*Mary Frances Vastine, M.D.*

Dobriner, Konrad, Kritchevsky, Theo. H., Fukushima, David K., Lieberman, Seymour, Gallagher, Thos. F., Hardy, James D., Jones, R. Norman, and Cilento, G. Infrared spectrometry in metabolic studies with deuterium-labeled steroids. *Science*, March 11, 1949, *109*, 260–261.

Infrared spectrometry, as an extremely sensitive tool for study of steroid metabolites, is aided by the use of deuterium steroids. Selection of proper fractions of metabolites for further study was rapidly accomplished by finding C-D absorption bands.—*E. C. Baker, M.D.*

Stead, G. The place of physics in the training of the medical radiologist. *Brit. J. Radiol.*, Aug., 1948, *21*, 373–379.

The author, in delivering the presidential address to the British Institute of Radiology, stresses the need for the radiologist to be well trained in physics. A historical résumé of the requirements for the British radiological cer-

tificate is given. The diagnostic radiologist is neither as interested in nor does he require the extensive training in physics required by the radiotherapist. Physics courses should be taught as understandably and be as easily understood as possible.

Radiological teaching in the United States and Canada is compared in its various aspects with that in England. In general, the author concludes that the English program better orients its graduates in the principles of physics than in practical, clinical application. He states that the converse exists in the Western Hemisphere. The teaching of the physical foundation of radiology is organized more systematically in England than in America.

The training of hospital physicists is emphasized and the creation of a diploma for this specialty is suggested. The closest collaboration and understanding between radiologists and physicists is mandatory for the highest degree of cooperation and success.—*K. L. Krabbenhoft, M.D.*

Szalay, A., and Csongor, Eve. Determination of radioactive content of rocks by means of Geiger-Müller counters. *Science*, Feb. 11, 1949, *109*, 146–147.

A Geiger-Müller counter shielded with 2 mm. of lead was placed against a rock wall and also within a bore in the rock. The increase in actual counts compared favorably with calculations of the possible rock content of K, U, and Th. This was checked by laboratory tests on samples of the same rock. The U concentration in unknown rock is x times 25 gU/metric ton of rock.—*E. C. Baker, M.D.*

Ramsey, G. H. S., Watson, J. S., Steinhausen, T. B., Thompson, J. J., Dreisinger, F., and Weinberg, S. Cinefluorography; a progress report on technical problems, dosage factors, and clinical impressions. *Radiology*, May, 1949, *52*, 684–690.

The authors use 35 mm. cinefluorographic equipment, running at 60 frames per second, with the aid of a high speed shuttle. Half-wave rectification has eliminated the necessity of a revolving lead shutter. Synchronization of the camera shutter with the power impulses is accomplished by the use of a synchronous motor to drive the camera. A semi-automatic system gradually builds up the motor speed. A three-second run results in the production of 180 images and uses $11\frac{1}{4}$ feet of film. Another 8 feet are wasted in starting the camera, about 4 feet for stopping.

The film magazine is protected with lead. The lens elements protect the film during the time the film is in or passing through the shuttle.

A DuPont-Patterson E-2 fluoroscopic screen and Kodak linagraph ortho film (green sensitive) are used. The factors used are 100 kv., and 75 to 150 ma. The half-value layer is 2 mm. Al, and an estimated threshold erythema is 350 r. At 150 ma., the tube output at 24 inches is 4.5 r per second. The target screen distance is altered from 29 to 50 inches, depending on the thickness of the part and whether or not a grid is employed.

The technical personnel is fully protected. One technician can carry out the entire procedure and usually only fully cooperative patients are used.

The exposure to the patient in any simple examination is limited to a maximum of 25 r. An added factor of safety is the low depth doses characteristic of roentgenographic exposure factors.

The developed negative is usually printed on fine grain 16 mm. positive type film, thus protecting the negative from damage and insuring a screen picture of superior projection quality. A careful study is best done by running the film through the projector as an endless loop.

The slow motion films are useful in the study of processes involving rapid motion, such as movements of joints, swallowing, heart action, the motion of pulmonary structures, and the passage of opaque medium through the alimentary tract and blood vessels.—*Benjamin Copleman, M.D.*

Pohle, Ernst A., Ritchie, Gorton, and Moir, William W. Studies of the effect of roentgen rays on healing of wounds; histological changes in skin wounds in rats following postoperative irradiation with very small and moderate doses. *Radiology*, May, 1949, *52*, 707–713.

After incision of the skin of rats various doses of 100 kv. radiation were applied at different time intervals, but none more than twenty-four hours later. Doses varied from 10 to 700 r. No difference of any importance in healing time was detected microscopically or histologically. Doses of 10 to 25 r appeared to cause a reduction in the amount of exudate in the wound

with less fibrin to be replaced by scar tissue.—*J. M. Dell, Jr., M.D.*

Warren, Shields, and Dixon, Frank. Effects of continuous radiation on chick embryos and developing chicks; growth rate, gonads, and bone. *Radiology*, May, 1949, *52*, 714–729.

A study of the effects of continuous irradiation by injection of P^{32} on chick embryos and young chicks was made. This is a detailed report on various tissues reactions. The P^{32} was injected into the yolk of incubated eggs and into the subcutaneous tissues of young chicks and rather extensive studies carried out. The concentration was mainly in bone causing an overall growth retardation. Testes and ovaries were found to be the most radiosensitive organs.—*J. M. Dell, Jr., M.D.*

Bloom, Margaret A., and Bloom, William. Late effects of radium and plutonium on bone. *Arch. Path.*, May, 1949, *47*, 494–511.

The effects of radium and plutonium administered in single small doses were studied in male and female mice. The radium was injected intraperitoneally giving doses of 0.3 microcurie per gram of weight and 0.03 microcurie per gram of weight. The plutonium was administered intravenously giving doses of 0.03 or 0.003 microcurie per gram. The animals were sacrificed and studied at various intervals after the administration of the radioactive substances. The abnormalities noted in the bones are attributed to the beta and alpha particles emanating from the radium and from the alpha particles emanating from the plutonium.

Radium and plutonium was found to produce an overgrowth of bone in the femurs and vertebrae. The most marked effect was noted in the metaphyses. The atypical bone is found to be different from callus, benign osteoma, or frank sarcoma. This new bone often is devitalized, showing empty lacunae, and showing a very close resemblance to Ewing's radiation osteitis.

There were no pathological fractures in the areas of devitalized overly dense bone. The medullary cavities were crowded by the early bony proliferation. Endosteal growth of bone was also increased. The new bone formed is unusually fibrous, and the trabeculae are thickened and increased in number. After plutonium, the trabecular thickening progresses to the formation of compact, spongy bone. There are fewer empty lacunae after plutonium than after radium. In 2 instances there was exceedingly rapidly formed new bone which simulated early sarcoma. There was no convincing evidence of increased incidence of leukemia in this particular series of animals.—*C. L. Hinkel, M.D.*

Editorial. Shoe-fitting fluoroscopes. *J.A.M.A.*, April 9, 1949, *139*, 1004–1005.

Radiation injuries to feet as the result of excess exposure by the use of shoe-fitting fluoroscopes have not been reported in the medical literature. However, there is inherent danger in the use of these machines by shoe salesmen for it is possible to deliver from 11 to 140 r per minute to the sole of the shoe.

Recommendations have been made to limit the exposure but no actual controls are now in effect.—*C. A. Stevenson, M.D.*

Gluecksmann, Alfred. The relation of radiosensitivity and radiocurability to the histology of tumor tissue. *Brit. J. Radiol.*, Nov., 1948, *21*, 559–566.

Published estimates of the radiosensitivity of various tumors are in general agreement as are five year survival figures, when these are all calculated for the same average incidence o late cases. In some instances the same five year survival rate is found for radiosensitive, moderately radiosensitive and radioresistant tumors.

Radiosensitivity is determined by the rate of shrinkage after irradiation. This rate depends on several factors. If a tumor is made up of rapidly dividing undifferentiated cells, the tumor mass may disappear rapidly as all the irradiated cells respond at once. If a tumor is made up of some rapidly dividing cells which become differentiated in their life cycle, the differentiated cells respond more slowly, but not less surely, to irradiation, and the tumor shrinks more slowly, but just as surely. Rate of tumor regression is largely a function of the proportion of short-lived undifferentiated cells in a tumor.

Radiocurability is measured by absence of recurrence in five years. Tumors which are accessible have a higher rate of radiocurability as they can be treated without subjecting a large volume of normal tissue to severe irradiation. Also, the average growth coefficient or rate of growth shows a close inverse correlation with the average five year cure rate. The

growth coefficient is also closely correlated with the tendency to regional metastatic spread. Lymph node involvement reduces the radiocurability because tumors with a tendency to lymph node involvement differ in their biology from other tumors. Anaplastic tumors have a high growth coefficient and a tendency to spread and are thus frequently radioresistant.

An analysis of carcinomas of the uterus shows that in general radiocurability is associated with the degree of differentiation. It must be kept in mind, however, that irradiation acts in three ways: by its effect on mitosis, by its direct lethal effect on resting cells, and by promoting differentiation of cells and thus preventing further division. This capacity for differentiation may be latent in an apparently anaplastic tumor and developed to its full limit in a differentiated tumor. This effect therefore might sterilize such an anaplastic type more completely than the tumor of lower histopathological grade. On the other hand, in an anaplastic type of tumor the cells capable of division are greater in number than in a differentiated tumor, and there is an increased chance that some may escape direct and indirect effects of irradiation.—*E. F. Lang, M.D.*

van Wagenen, G., and Jenkins, Ralph H. Pyeloureteral dilatation of pregnancy after death of the fetus; experimental study. *Am. J. Obst. & Gynec.*, Dec., 1948, *56*, 1146–1150.

Spontaneous fetal death occurred in three rhesus monkeys. The placenta in each instance remained active hormonally in respect to the mother. In these animals, the placental hormones become effective on the ureters, as on all smooth muscle, about the thirty-fifth day of gestation. (Pregnancy lasts approximately six months and the fetal skeleton is visible on the roentgenogram at about seventy days.) Dilatation of the upper urinary tract was demonstrated in these animals by the injection of diodrast intravenously and exposure of roentgen fims.

In previous experimental studies, the same set of circumstances was established by surgical removal of the fetus alone before establishment of the definitive placenta. In these animals, pyeloureteral dilatation was demonstrated to arise and be maintained, despite fetal absence.

The present study is taken as further proof of the belief that the ureteral dilatation of pregnancy is a function of the maternal placental surface, and is not dependent upon the presence or the weight of the fetus.

The case histories of these three monkeys are presented.—*Mary Helen Cameron, M.D.*

Barclay, A. E., and Leatherdale, Donald. Microradiography applied to botany. *Brit. J. Radiol.*, Nov., 1948, *21*, 544–551.

Prior to the described botanical application of microradiographic techniques, only very soft roentgen rays (such as grenz rays), were used in this field. The methods used previously in microarteriography are applied to botanical specimens. The possible future use of these techniques in the detection of drugs in situ or determining their site of action as well as determining further the structures of tissues is postulated.—*K. L. Krabbenhoft, M.D.*

Genaud, P. E. Le syndrome clinique des irradiés par l'explosion atomique. (Clinical syndrome in individuals irradiated by atomic explosion.) *Presse méd.*, May 21, 1949, *33*, 443–444.

It is only after many years that an exact description of the syndrome produced by the atomic bomb can be given. According to the author, some information hastily put forth has not been confirmed and certain other facts had not been considered in the early publications.

A study is presented of pathological conditions observed in the organs which are particularly radiosensitive: blood forming organs, digestive tract, epidermis, sexual glands in men and women, and of the clinical features (hyperacute, acute, subacute forms) which are determined by the severity of the early symtoms, the duration of the latent period, severity of recrudescence, and mortality incidence. As to the remote consequences of the irradiation (biologically) the gravest sequelae are due to radiomutation. The permanent Commission for investigation of the effects of the A-bomb are carrying out their studies on living material of rapid generation (plants, animals, *Drosophila*) and on children of the survivors who were in the area of the explosion but as yet no precise statements can be made.—*William M. Loehr, M.D.*

Moore, Alice E. Effect of inoculation of the viruses of influenza A and herpes simplex on the growth of transplantable tumors in mice. *Cancer*, May, 1949, *2*, 516–524.

This report reviews the literature concerning the behavior of various types of viruses on tumor tissues. Viruses with affinity for certain tissues such as the nervous system tend to grow more readily in tumors and tumor cultures. In some an interference with the growth or proliferative power of the tumor was induced by the virus contamination.

The article presents the experimental methods used in testing the effect of influenza A and herpes simplex on crocker mouse sarcoma 180 and mouse adenocarcinoma EO771. Following direct inoculation into sarcoma 180, the influenza virus could be detected for three days and herpes virus for five days. Direct inoculation of carcinoma EO771 yielded no virus parasitization with influenza A after three to four days, and herpes was present in only small amounts from four to six days. The herpes virus infected sarcoma 180 could be transferred four times in several passages before the virus disappeared. Influenza infected sarcoma lost the virus on the first transfer. It was impossible to infect sarcoma 180 when herpes virus was injected either intracerebrally or intraperitoneally even though lethal doses were administered.

The presence of both viruses in these tumors had no effect on the tumor growth.—*J. A. Campbell, M.D.*

Warren, Shields, and Dixon, Frank L. Effects of continuous radiation on chick embryos and developing chicks. II. Bone marrow, lymphoid tissue, and peripheral blood. *Radiology*, June, 1949, *52*, 869–880.

This is the second of a series of articles to show the effect on chick embryos and developing chicks, the eggs of which or the newly hatched fowl having been subjected to injections of P^{32} in the form of KH_2PO_4. It was found that the greatest concentration of the radioactive substance was within bone marrow and therefore the effect on blood forming tissues was the greatest. The extent of the effect of irradiation on the bone marrow was found to depend on the amount given. The same two basic effects, however, were always seen: inhibition of normal maturation and depression of mitotic activity. This process, however, was seen to be reversible and temporary inasmuch as normal maturation and mitosis were resumed after the irradiation ceased. Even when the dosage was sufficient to be lethal, some regeneration was noted. It was found that the reticulo-endothelial cells in the marrow suffered relatively little from the irradiation.

In the lymphoid tissue it was found that the response to irradiation was thorough and very profound. The sensitivity of the lymphocytes to irradiation was well demonstrated by a marked suppression of mitotic activity. At the same time regeneration of lymphoid tissue was rapid and started very soon after injury. This was followed by complete recovery unless the doses were large enough to be lethal.

In the peripheral blood counts, as might be anticipated from the above, the lymphocyte count was affected earliest and fell most sharply and the return to normal depended upon the intensity of the initial dose. The granulocytes dropped more gradually and their recovery was slower. The red blood cell count did not change as abruptly but gradually dropped over a period of fifteen or twenty days. The recovery phase was only slightly longer than for lymphocytes.— *Arthur J. Present, M.D.*

Hoecker, Frank E., and Roofe, Paul O. Structural differences on bone matrix associated with metabolized radium. *Radiology*, June, 1949, *52*, 856–865.

This paper presents preliminary results from studies of distribution of radium metabolically deposited in rat tibias and femurs. Recently developed techniques for sectioning these bones and for autoradiography are described in some detail.

Localized concentrations of radium were demonstrated; they were invariably associated with areas of optical density. The tissue reaction produced about the localized radium in the zone where a sublethal dose of alpha particle bombardment occurs may offer a reasonable basis for the production of bone sarcomas in chronic radium poisoning.—*H. G. Moehring, M.D.*

Friedenwald, Jonas S., and Crowell, Jane E. Histochemical studies on nucleic acid phosphatase. *Bull. Johns Hopkins Hosp.*, June, 1949, *84*, 568–582.

The article treats in detail the technique used in histochemical studies on nucleic acid phosphatase. One conclusion reached pertinent to radiology is that inhibition of mitosis in cells caused by heavy doses of roentgen radiation, ultraviolet and nitrogen mustard is not brought about by inhibiting or disorganizing

the nucleic acid phosphatase system.—*J. J. Wiesner, M.D.*

Trout, E. Dale, Graves, D. E., and Slauson, D. B. High kilovoltage radiography. *Radiology*, May, 1949, *52*, 669–683.

In 1944, Files and his co-workers began some work in search of an optimum ratio grid. It was found that grid ratios greater than 8:1 were feasible and that they greatly reduced the amount of scattered radiation reaching the film. At the increased ratios (as high as 34:1), the exposure time became so great that higher voltage was necessary. As the voltage was increased, the exposure time decreased, but at a rate considerably in excess of that expected. Also, the higher ratio grids made possible a high degree of contrast at voltages much higher than those in general use. A ratio of 16:1 was about the optimum.

After Files' death, Trout and his coworkers continued the investigation. The use of voltages up to 130 kv. (peak) proved possible without major redesign of equipment, providing proper consideration was given to the method of switching used to initiate and terminate exposures. A "synchronous" time may be used up to 120 kv. (peak), an impulse time is mandatory above that level and is advisable at any voltage where its timing range is adequate. The use of a reciprocating Bucky mechanism makes it possible to use the higher voltages without loss of contrast. With the higher voltages, latitude is increased greatly, patient dose and exposure time are sharply reduced.—*George Cooper, Jr., M.D.*

Morgan, Russell H., and Van Allen, Willard W. The sensitometry of roentgenographic films and screens. *Radiology*, June, 1949 *52*, 832–845.

A sensitometry laboratory for measuring the relative speeds of roentgen films, screens, and developing materials has been established by the United States Public Health Service. The authors define the speed of a roentgen film as the reciprocal of the exposure required to produce a film density of 1.0 above fog density and the density of the film base, with the unit of roentgen exposure measured in deciroentgens (0.1 r). This definition of film speed applies whether exposures are made with or without intensifying screens.

The authors established rigid specifications for all of the factors which affect film exposure, and film density, with the following results: (1) time of exposure 1.0 second; (2) quality of the exposing radiation equivalent to a half-value layer of 4.0 mm. of aluminum; (3) temperature of the film at exposure 25° C.; (4) temperature of the developer during processing 20° C.; (5) time of development as recommended by the manufacturer of the developer; (6) continuous agitation of the developer during development by paddles moving at an average speed of 2 to 4 inches per second.

The authors describe and illustrate their methods and apparatus for measuring the speeds of various film-developer and film-screen-developer combinations.

The data which are being gathered in the sensitometry laboratory, under the above carefully specified and controlled conditions, will prove to be of inestimable value to the roentgenologist, in selecting the most efficient of the commercially available roentgenographic supplies. The paper is quite technical and all radiologists who are interested in the details of determining film speed are urged to read the original article.—*George P. Keefer, M.D.*

Zirkle, Raymond E. Relationships between chemical and biological effects of ionizing radiations. *Radiology*, June, 1949, *52*, 846–855.

The mechanism of radiobiological action as understood today is summarized. The first event in the mechanism is absorption of radiant energy by the molecules which are then said to be *activated*. Those molecules which absorb so much energy that electrons are ejected are said to be *ionized*. Those which absorb only enough energy to shift electrons to other orbits are said to be *exited*.

After absorption of energy there is no further visible effect until biologic effects appear. The intervening—or *latent period*—is little understood, but most workers consider that a chain of chemical events takes place.

The author then concludes that chemical events do take place during the latent period and he proceeds to discuss in detail the nature of the chemical events and the manner in which they lead to the biological effects.

The article is highly theoretical and the laborious procedure used in arriving at an understanding of the mechanisms of radiobiological actions is illustrated. Those interested in radiobiology should read the original article. —*Richard E. Kinzer, M.D.*

Morgan, Russell H. Physical problems of fluoroscopy and spot-film radiography. *Radiology*, June, 1949, *52*, 786–795.

This article divides the problems of fluoroscopy and spot-film roentgenography into those concerned with radiation hazards to which the patient and the radiologist are exposed during the performance of the procedures and those concerned with the poor visibility which prevails during any fluoroscopic examination especially during the fluoroscopic study of such heavy structures as the abdomen.

Radiation Hazards. The deleterious biological effect of roentgen radiation on tissue necessitates that radiation to which the patient is exposed during particularly the gastrointestinal study be maintained at low value. This may be done by observing and/or changing the following:

Keep the fluoroscopic aperture as small as possible consistent with an adequate study of anatomical relationships.

Keep the time of exposure at the shortest possible, consistent with a complete examination.

Increase kilovoltage during fluoroscopy and decrease the amount of milliamperage necessary

Increase the conventional amount of filtration.

Increase the target-table top distance.

Fluoroscopic apertures of 200 square inches with exposure period of ten to fifteen minutes should be condemned. The great majority of gastrointestinal examinations need not be prolonged beyond the period of five minutes of actual fluoroscopy by the average radiologist. Increasing kilovoltage and decreasing milliamperage diminishes the non-absorbable long wave components in the fluoroscopic beam. Increase in the filtration reduces radiation dosage at very little cost in extra milliamperage needed to maintain the screen at its original brightness. Increasing target distance is not as much protection as might be anticipated but gives some protection in that increasing target distance from 15 to 20 inches only decreases the dosage rate by 16 per cent.

There seems to be little basis for apprehension concerning the quantity of radiation delivered to the patient during spot-film roentgenography. The author shows by phantom test that the amount of radiation exposure, making a series of spot roentgenograms, constitutes only 10 to 25 per cent of the total radiation a patient receives during a fluoroscopic study.

Use of compression devices in spot-film roentgenography is discussed and the author states that the most desirable field limiting devices should always be between the roentgen tube and the patient unless some automatic mechanism is provided to limit the shutter opening when the device is in place.

Any general procedure which reduces the radiation exposure to the patient also reduces the exposure to the fluoroscopist. Additional protection for the fluoroscopist is afforded by the use of lead gloves and lead aprons. The most effective use of the protective materials by any given fluoroscopist can be determined, however, only with a knowledge of radiation exposure conditions about his fluoroscope.

Fluoroscopic Visibility. The poor visibility which prevails during fluoroscopy is well known and is due to the relatively large statistical fluctuations which exist from moment to moment in intensity of fluoroscopic beam. This will be reduced when an electronic screen intensifier becomes available.

The function of size of image and contrast exhibited during fluoroscopic visibility is discussed.

Spot-film roentgenography has been utilized to supplement poor fluoroscopic visibility and spot film techniques may be improved by use of fine focus, rotating anode tubes and stationary grids, also fluoroscopic images improved by use of stationary grids. The installation of automatic phototiming devices on spot-film carriage is helpful.

Seven physical graphs are presented including isodose charts showing exposure in milliroentgens per hour about a fluoroscope used by the author.—*John H. Gilmore, M.D.*